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MAKING AUTOMOBILE TIRES BY ELECTRICITY

DETAILS OF A PLANT DESIGNED AND INSTALLED BY THE ENGINEER WHO OPERATES IT

ALTHOUGH THE PLANT of the Kelly-Racine Rubber Co., of Racine, Wis., is not large, from the modern point of view, it is modern, complete, convenient and simple and embraces all that is desirable for continuous and economical operation and at the same time will permit of future additions in all departments with promptness and dispatch.

The plant is entirely new. Excavations were commenced on the 12-acre site late in June, 1910; August 1 the brickwork was about even with the ground level at one end, while excavation was not yet completed at the opposite end of the works. Yet so perfect was the system inaugurated by the management, that steam was raised in the boilers Christmas Day, 1910, and on Dec. 31, the first tires were made and the works have been in continuous operations since without a shut down.

Not only have the works run continuously for man-

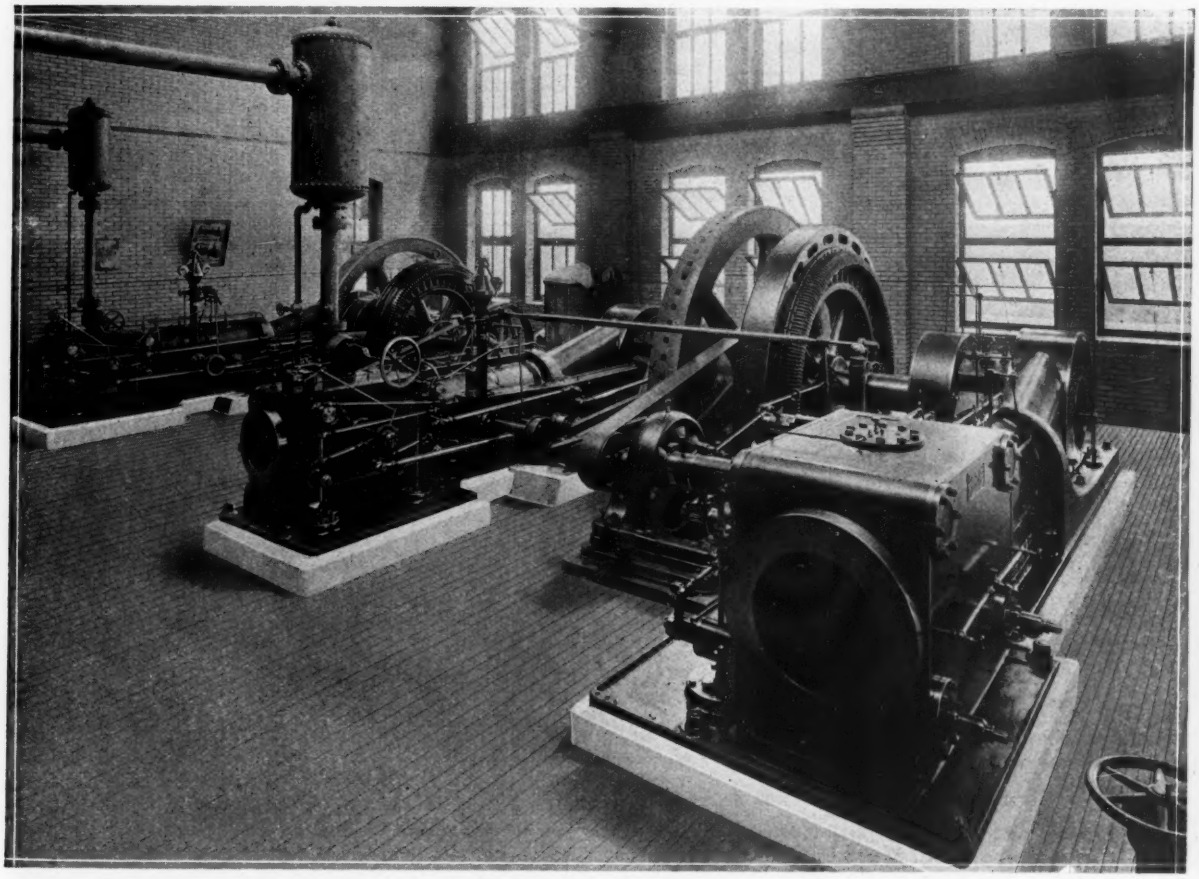


FIG. 2. WISCONSIN ENGINES AND FT. WAYNE GENERATORS AND EXCITERS

ufacturing purposes, but during the time that the local plant of the Milwaukee Electric Railway and Light Co. was out of commission, owing to complete destruction by fire March 9, connections from the city power and lighting circuits were hastily made with the power house of the Kelly-Racine Rubber Co. and night and day, their engines worked under an overload that

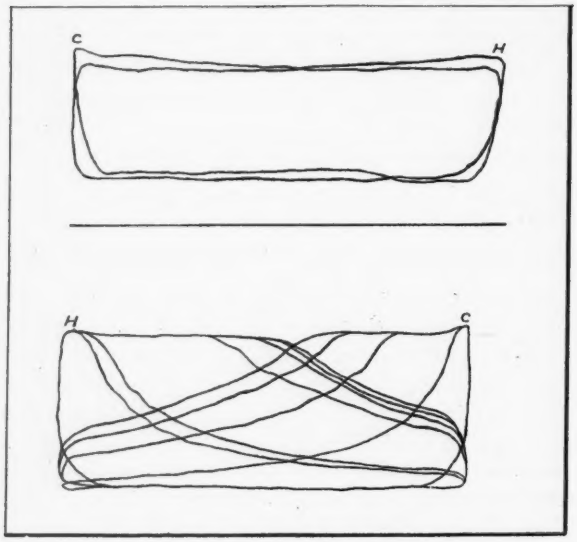


FIG. 2A. CARDS SHOWING THE HEAVY OVERLOADS AND WIDE VARIATIONS TO BE CARED FOR

would wreck the average generating outfit, and kept Racine supplied with light and power until the local street railway power house was again in operation. In all this gruelling experience, there was not the slightest mishap or inconvenience of any kind to any part of the power house equipment.

Location and Arrangement

THIS plant is located on the south side of Racine with the tracks of the C. M. & St. P. R. R. on one side and those of the Belt Line on the other, with switches from their lines and the C. & N. W. R. R. running to the plant when convenience requires. The Chicago and Milwaukee Electric R. R. line is located to the west, giving an outlet for both freight and express in addition to passenger service, with trains every hour each way. Racine is located on one of the best harbors on the Great Lakes and the facilities offered by the several lake transportation companies for prompt service are not surpassed anywhere.

The factory proper is of brick 217 by 264 ft. in area, 3 stories and basement, and of mill construction, suitably equipped with ample light and ventilation, while elevators are located centrally for the rapid and convenient handling of the products.

To the south of the main building is located the mill room 50 by 196 ft., the roof of which is supported by structural steel. This gives a clear space for the convenient location of the several mill and washer lines, calenders, driers, etc., and taken as a whole, the factory is so equipped, and the machinery so arranged by means of electric drive, that the material passes consecutively from one department to the next with the minimum amount of handling.

To the south of the mill room and separated from it by a 10-ft. alley and a fire wall is the power house proper, 137 ft. 5 in. by 46 ft. 6 in. outside, being divided into the engine room, 78 by 44 ft., and the boiler room, 55 ft. 3 in. by 44 ft. in the clear.

The engine room is lined throughout with cream pressed brick with a border of red pressed brick around the entire room 14 ft. from the floor. In Fig. 1 is clearly shown the general arrangement of the engines, boilers, pumps, piping, etc., and needs no further comment.

Generating Units

POWER equipment as shown in Fig. 2, consists of 2 Corliss engines; one 11 by 30 simple direct connected to a 100 k.v.a. Ft. Wayne 240-volt, 3-phase, 60-cycle alternator, running 164 r.p.m. with an 8-kw. independent exciter. The other unit is a cross-compound 15 and 26 by 36 in., also direct connected to a 500 k.v.a., 240-volt 60-cycle alternator running 150 r.p.m. with a 20-kw. independent exciter.

Both engines were made by the Wisconsin Engine Co. of Corliss, Wis., and are of its heavy duty rolling mill type equipped with double ported valves, double

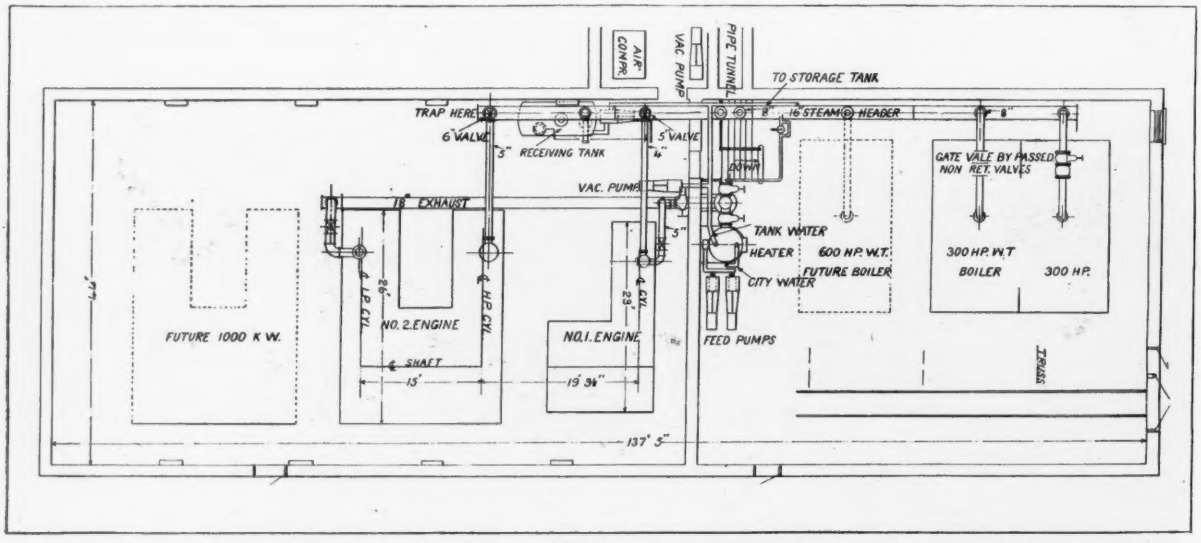


FIG. I. PLAN OF ENGINE AND BOILER ROOM AT KELLEY-RACINE RUBBER COMPANY'S PLANT

eccentrics and long range valve gear, giving a possible maximum cut off of 82 per cent of the stroke which is fully shown in one of the accompanying indicator cards. The governors are of the high speed type running 224 r.p.m., fully equipped with the proper safety appliances and each is provided with a synchronizing device whereby the units can readily be operated successfully in parallel.

Both engines are equipped with Richardson cylinder oil pumps, single and double feed for the simple and compound units, respectively. The discharge from these pumps to the cylinders is tapped conveniently and a branch pipe run over to each piston rod where the supply of cylinder oil can be regulated from nothing to several drops per minute as required.

Main bearing shells are adjustable in such a manner that the shaft can readily be kept in line and also maintain proper clearance in the alternators. Telescopic oilers are provided for the crosshead pins, and all eccentrics and the crank pins equipped with centrifugal oilers all supplied from the oiling system as will be shown.

On account of the high speed, grease cups were chosen for lubricating the side rod brass heads and the carrier arm pins, and have proven a clean and effective method of lubrication, no unsightly oil pans being required. Each unit drives its own exciter by means of a belt from the engine shaft as is shown in the illustrations. Cook's Metallic Packing, made by the C. Lee Cook Mfg. Co., Louisville, Ky., is used on all piston rods.

Indicator cards shown in Fig. 2-A will give some idea of the overloads that are carried at times. No. 1 is from the high-pressure cylinder of the compound engine during an exceptional overload for 2 hours duration, continuously. No. 2 is from the simple engine which had been direct connected to one of the 24 by 66-in. calenders around the switchboard for the purpose, and shows the fluctuating loads met with in rubber works.

which necessarily must be oiled by hand. Waste oil drains by gravity to a White Star oil filter, Fig. 3, supplied by the Pittsburgh Gage & Supply Co., lo-

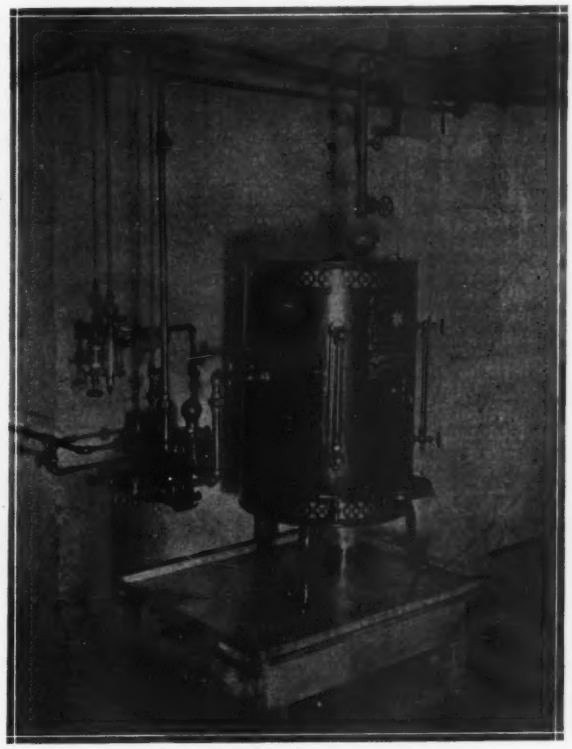


FIG. 3. OIL FILTER AND PUMP

cated in the basement where the oil, after filtering, is pumped by a Marsh size B, oil pump 2½ by 1⅜ by 2 in. to a tank located on the wall of the boiler room as

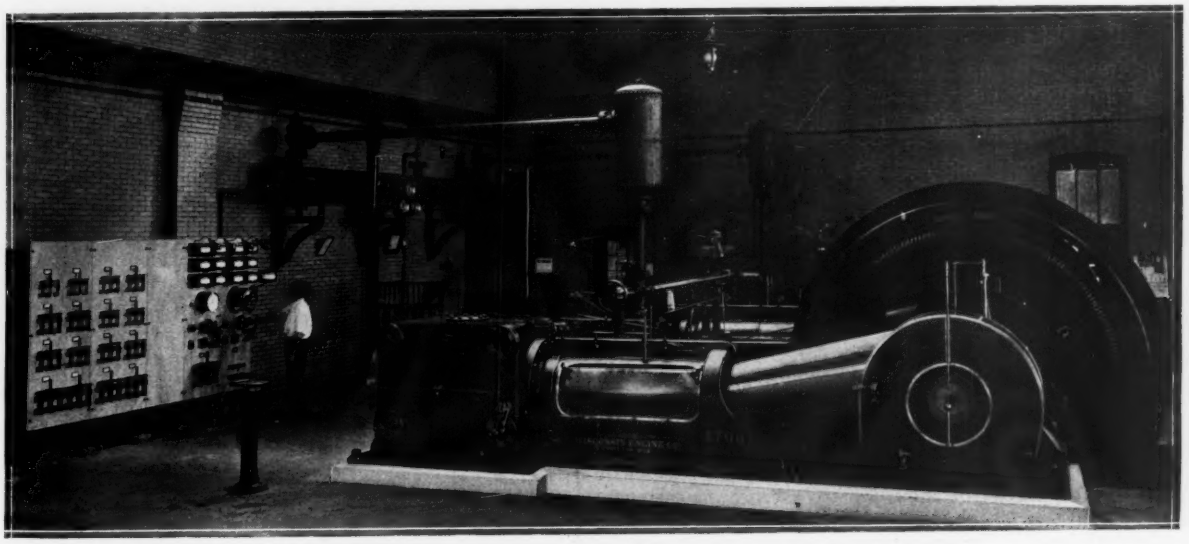


FIG. 4. SWITCHBOARD AND STEAM HEADER IN THE ENGINE ROOM

Oiling System

BOTH engines are equipped with a complete oiling system whereby oil is supplied to every bearing in any quantity desired, except the valve gear proper shown in Fig. 10, whence it runs by gravity to the engines through a 1-in. main under the floor, giving a pressure of about 8 lb. at the bearings.

This pump is cross connected in such a manner,

that should it be necessary for any reason whatever, to cut out the overhead tank, the pump can be arranged to deliver direct from the filter to the oil mains, a suitable relief valve and gage being provided to maintain the proper pressure. The oil pump is also arranged to pump new oil directly from the barrel if necessary, to either the oil filter or the oiling system.

A single valve controls the entire supply of oil to each engine and in starting up or shutting down, it is necessary only to open or close this valve to provide ample lubrication on all bearings, thus eliminating entirely the tedious and wasteful job of filling individual cups on every bearing and carefully adjusting them frequently. With the abundant supply of oil flowing continuously over every bearing, friction is reduced to the lowest possible point and this feature alone adds greatly to the economy of the plant.

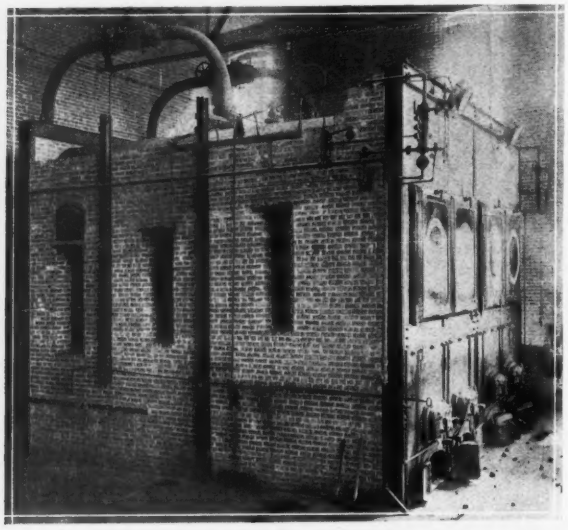


FIG. 5. BOILERS AND BOILER ROOM PIPING

In the west end of the engine room has been left space where a unit of 1200 k.v.a. capacity can be installed in future when necessary; the power house can be further extended to make room for another unit of the same size. A 24-ton crane, built by the Northern Engineering Works of Detroit, Mich., serves the entire engine room and is high enough and sufficiently substantial, to handle any machinery ever likely to be installed.

Piping System

SUPPORTED on brackets along the north wall of the engine and boiler rooms, is located the main steam header, 76 ft. 6 in. long, of the welded flange and nozzle type, made by the M. W. Kellogg Co., New York. This header is made in 3 sections, the longest of which, back of the present and future boilers, is 30 ft. 6 in. long. This header is of steel ⅜ in. thick and 16 in. outside diameter, pitched slightly in the direction of the flow of the steam toward the engine room. At the west end is located a 2-in. drain pipe where the condensation passes to the basement and is taken care of by a Colles No. 4 trap which returns the condensation to a receiver pump, mention of which will be made later.

Outlets to the engines (as well as all other openings for steam and for the boiler connections) are on the top of the header, where are located extra heavy Kelly-Jones ferrosteel angle valves with bypasses, the steam passing direct to Colles receiver separators of the angle type located above the throttle valves as shown, which gives absolutely dry steam at boiler pressure at the throttle under the most severe demands for power. The angle separator, traps, heater, and other Colles fixtures were furnished by the E. G. T. Colles Co., of Chicago.

The throttle valve of each engine is bypassed for warming up purposes while the compound engine is provided with an additional bypass direct to the receiver which makes it possible to start the engine from any position, the crank pins being set at 90 deg. to each other.

By a unique system of piping, the drainage of both steam separators and the bleeders on the throttle valves (when the engines are not in operation) are taken care of by a Colles No. 5 trap located in the basement, which also discharges into the receiver of the receiver pump above mentioned.

Switch Board

THIS is of polished slate containing 4 panels, 2 for the feeders, one blank panel and 2 for generator control. All slate is 1½ in. in thickness with bevel joints and an angle iron frame braced to the wall behind. Subpanels extend below the switchboard floor and are 1¼ in. thick by 12½ in. high. All the main panels are 72 in. high and the feeder panels are 32 in. wide the blank and generator panels being 24 in. wide. On the No. 1 panel are controlled 4 power feeders, one compensator and 3 single-phase feeders for 3 wire lighting. The power feeders are 2 for 600 amperes each and 2 for 400 amperes; the compensator feeders have a capacity of 400 amperes, and the lighting circuits are 200 amperes each.

Number 2 panel carries 8 power feeders, 2 of 600 amperes, 2 of 400, and 4 of 300 amperes. No. 3 panel is for the 500 k.v.a. generator and carries an ammeter for each phase and one for field current. There are also a wattmeter and voltmeter, and plugs are provided for connection to the exciter voltmeter. On this panel is a synochronizing instrument for throwing the generators in parallel, and a 1500-ampere switch for connecting the generators to the bus bars.

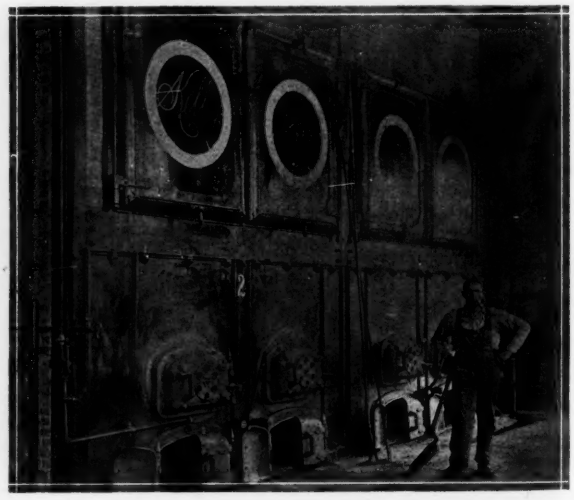


FIG. 6. THE IMPORTED HIBERNIAN STOKER

Number 4 panel controls the 100 k.v.a. generating unit, and has the same provision of instruments as

No. 3 panel, except that in place of the synochronizer is a recording wattmeter which registers the total output of the plant. To the right of this panel on a swinging arm is a direct current voltmeter which may be connected to the 2 exciters, as needed.

Boiler Details

IN the boiler room are located 2 300-hp. water-tube boilers of the Freeman-Bonus patent made and installed by S. Freeman & Sons Mfg. Co., Racine. These are illustrated in Figs. 5 and 7 which show the general arrangement.

Each boiler contains 3000 sq. ft. of heating surface and contains 149 4-in. tubes, No. 9 gage, 18 ft. long, of hot drawn seamless steel staggered and inclined 1½ in. per foot. Each boiler has 2 steam drums 36 in. in diameter and 20 ft. long made of ⅜-in. steel, with circular seams single riveted, and horizontal seams triple riveted and double butt strapped. The rear heads are dished and each contains an 11 by 15 Cahall patent swinging manhole cover which fits accurately to the edge of the sheet which has been flanged in and dressed to a plane surface.

Box headers or manifolds are constructed of ⅝-in. steel stayed with 1⅜-in. solid stay bolts spaced 6 11/16-

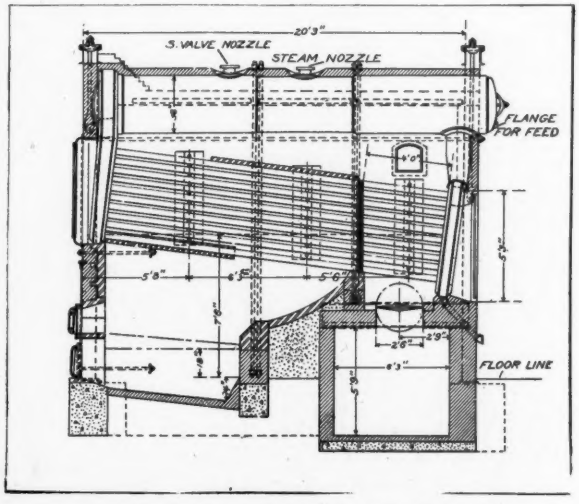


FIG. 7. SECTION OF BOILER AND SETTING

in. horizontally and 5¾-in. vertically. The rear sheet of the front manifold is flanged outward for the drums and the drums securely riveted on while ample braces riveted to the shell pass through the opening and are riveted to the front sheet of the manifold. Connecting the bottom of each drum with the top of the rear manifolds is a circulating pipe 15 by 19 in. and eliptical in form securely riveted in place. Thus providing for all difference in expansion that can possibly occur, and at the same time for a rapid circulation of the water.

Open hearth homogeneous flange steel of a tensile strength of 57,000 to 65,000 lb. per sq. in. and an elastic limit not to exceed 32,000 lb. is used throughout and all sheets were punched ⅜ in. small and afterwards reamed to size in place after the various sheets were securely bolted together, which insures all rivet holes to be absolutely square and in line.

Hand holes in the manifolds opposite the ends of the tubes as well as for the tubes, are drilled out by a lip drill of special design which eliminates any tendency to crystalize and crack the sheet.

A 6-in. nozzle is securely riveted to the top of each of the drums on each boiler, which are joined by a steel double pipe having an 8-in. outlet for the steam main. Five-inch steel nozzles are also riveted to each drum to which are bolted 3½-in. American nickel seat safety valves of the spring type.

The rear manifold extends 10 in. below the lower row of tubes as is shown in Fig. 7 which provides an

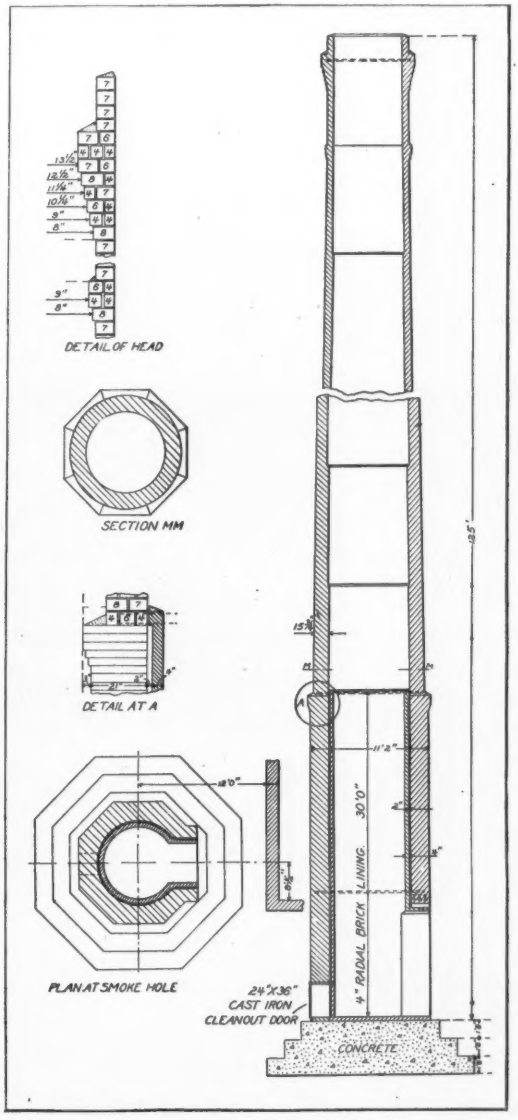


FIG. 8. SECTIONS OF BRICK CHIMNEY AND FOUNDATION

ample settling chamber for mud entirely removed from the influences of the flue gases. Each boiler is provided with 2 2½-in. extra heavy blowoff pipes screwed into ample reinforcing plates riveted to the bottom of the rear manifolds. Crane ferrosteel blowoff valves backed up by a 2½-in. Okaydee lever gate valve are used, the blowoff pipe emptying into a blowoff tank located outside of the boiler room where a 3-in. vent pipe rising several feet above the surrounding buildings and a 3-in. connection to the sewer, dispose of vapor and water..

Steam in leaving the double pipes of the boiler, passes through an 8-in loop shown in Fig. 5, at the top of which is located an 8-in. Kelly-Jones ferrosteel

gate valve suitably bypassed; located on the side toward the header and beside it, next to the boiler, is an Erwood double acting nonreturn valve which is suitably arranged to cut out all the boilers in case of serious rupture in the piping system, or to cut any boiler out from the line in case of rupture of any of the tubes, etc.

Location of these valves at the top of the loops as shown, absolutely prevents water pockets and consequent drainage troubles. There is no place in the entire steam line where it is possible for water to collect even in small quantities and the location of the loops over the boilers and their large capacity, together with the ample provisions made throughout the power house for distributing the steam, preclude all possibility of priming or carrying of water along with the steam at any of the outlets under the most severe demands for steam.

Space has been left in the boiler room to install a future boiler of about 600 hp., while the boiler room is designed for future extension on the east side of the stack when necessity demands additional power.

FIG. 9. 18-IN. EXHAUST STEAM HEADER IN BASEMENT

Boilers as shown in Fig. 7, are suspended by means of 4 2-in. eye bolts each, from a structural steel frame work, which is amply protected from the influences of the heat by the brick work. This allows a certain freedom of movement which is necessary on account of the expansion due to high pressure and which could not be secured by supporting the boiler in any other manner.

Twelve-inch illuminated American steam gages, Reliance water columns with high and low water alarms, equipped with Ohio gage cocks, and water glass connections complete the boiler equipment.

Hollow stay bolts are provided in both front and rear manifolds, immediately over the brick arch by means of which the arch can be thoroughly cleaned by a steam blower as required, while 3 blower frames are located at the sides of each boiler as shown in Fig. 5, through which the tubes can be quickly cleaned of soot.

Each boiler is equipped with Martin rocking grates, 80 by 100 in., furnished by the Martin Grate Co., of Chicago and are hand fired by means of the "Hibernian Stoker" shown in Fig. 6. Dennay Kilbane is one of the few real firemen that one frequently hears about but seldom encounters. Under the fluctuating and severe load conditions, the steam is held right on the dot and the results obtained from the fuel are indeed pleasing to see.

Uptake and Chimney

GASES travel through a system of baffles clearly shown in Fig. 7, which brings the hottest gases in contact with the heating surface where the temperature of the water in the boiler is the highest and passes downward to the underground smoke conduit at the rear of the boiler where both the water and the gases are at the lowest temperature. In this way is obtained the greatest possible efficiency from the fuel.

The gases, after entering the underground conduit, pass to the stack located outside of the boiler room to the east, fully shown in Fig. 8. This stack, which regularly develops a draft of 0.8 in. water pressure, is 125 ft. high by 6 ft. 6. in internal diameter, and was erected by the Heine Chimney Co., of Chicago, its celebrated interlocking tile being used. The stack is equipped with 2 lightning rods of ample proportions, supplied by the Ajax Lightning Rod Co., also of Chicago.

Handling of Exhaust Steam

EXHAUST steam from all engines and pumps wherever located, enters the 18-in. exhaust header in the engine room basement, shown in Fig. 9. This extends through the wall as shown and turns upwards on a heavy 18-in. base elbow, resting on a concrete foundtion. A Colles separator is provided as shown, Fig. 10, which completly removes all oil and condensation from the exhaust steam before entering the heating system and steam utilized to heat the feed water upon entering the Colles heater, encounters another oil separator which is a part of the heater. Drainage from both these separators is collected by a Colles grease trap which discharges direct to the sewer.

At the side of the 18-in. separator in the exhaust pipe, which is 48-in. in diameter and 6 ft. 6 in. high, is located a 10-in. opening connecting with a Colles open heater of the induction type, of a rated capacity of 1500 hp., sufficient exhaust steam being drawn in through the 10-in. valve as shown, to heat the feed water at all times to 212 deg. F. This heater is suitably vented at the top to the exhaust pipe above the back pressure valve.

Feed Water Control

FROM the heater, the hot water flows by gravity to 2 Epping-Carpenter duplex boiler feed pumps, 10 and 5 by 10 in. through a 5-in. suction pipe. These pumps are duplicates, of the center packed plunger type, and deliver the feed water to a 3-in. main running in a concrete conduit beneath the floor in front of the boilers, and equipped with suitable steel covers that can be removed to inspect or repair the main if necessary.

From this main, is taken a 2-in. branch leading to each boiler where the hot feed water enters the rear of the boiler drums and overflows from a mud pan which is suitably arranged for blowing out when necessary. In this 2-in. supply to each boiler, is located a Copes feed water regulator which maintains a constant water level continuously in the boilers.

In the steam line leading to the feed pumps is located a Copes pump governor in such a manner that it will control the speed of either or both pumps and always maintain a constant pressure in the feed main of 20 lb. in excess of boiler pressure. These Copes fixtures are made by the Northern Equipment Co., and their performance is so satisfactory that frequently, for several weeks, no attention beyond oiling, is required to either the pumps or the hand regulation valve with which the feed lines are equipped.

Each feed pump is equipped with a Hills-McCanna force feed cylinder oil pump which supplies oil directly in proportion to the speed of the pump. The oil is delivered into the steam main back of the pump governor so that the governor is thoroughly lubricated and kept in the best possible condition by the oil passing through it.

Immediately above the oil and steam separator in the exhaust pipe, is located an 18 by 18 by 12-in. tee from which is taken the exhaust steam for heating purposes, with suitable bypass arrangements, as shown in Fig. 10, for live steam heating. Above the tee is an 18-in. Colles balanced, noiseless back pressure valve by which any desired back pressure up to 5 lb. can be maintained on the exhaust main.

Above the back pressure valve is a spiral riveted 18-in. pipe extending up through the concrete roof of the boiler room where it terminates in a Colles exhaust head, shown in Fig. 11. This exhaust head is 54 in. in. diameter and 8 ft. 6 in. high, delivering the surplus exhaust steam high above the ventilators in the skylights of the engine and boiler rooms.

Figure 11 also shows the whistles. These are of the Lunkenheimer standard extra long bell, 6 and 8 in. diameter of bell and are piped as shown and blown simultaneously by means of a 3-in. balanced whistle valve directly over the main steam header.

The heating main leading to the factory, as mentioned above, is 10 in. diameter and supplies radiators located along the walls as required for the proper temperature of the various departments. Returns are taken care of by a Knowles vacuum pump 5½ by 8 by 10 in. equipped with a vacuum governor. This pump discharges into a 1000-gal. tank located near the ceiling in the boiler room, to the right of and just off the illustration shown in Fig. 10.

This is high enough to permit of the water flowing into the feed-water heater at 5 lb. back pressure if necessary, although it was never necessary to carry more than a pound back pressure the coldest weather during the past winter. The entire heating system was installed by the Thomas Heating Co., of Racine, the Paul vacuum system being used.

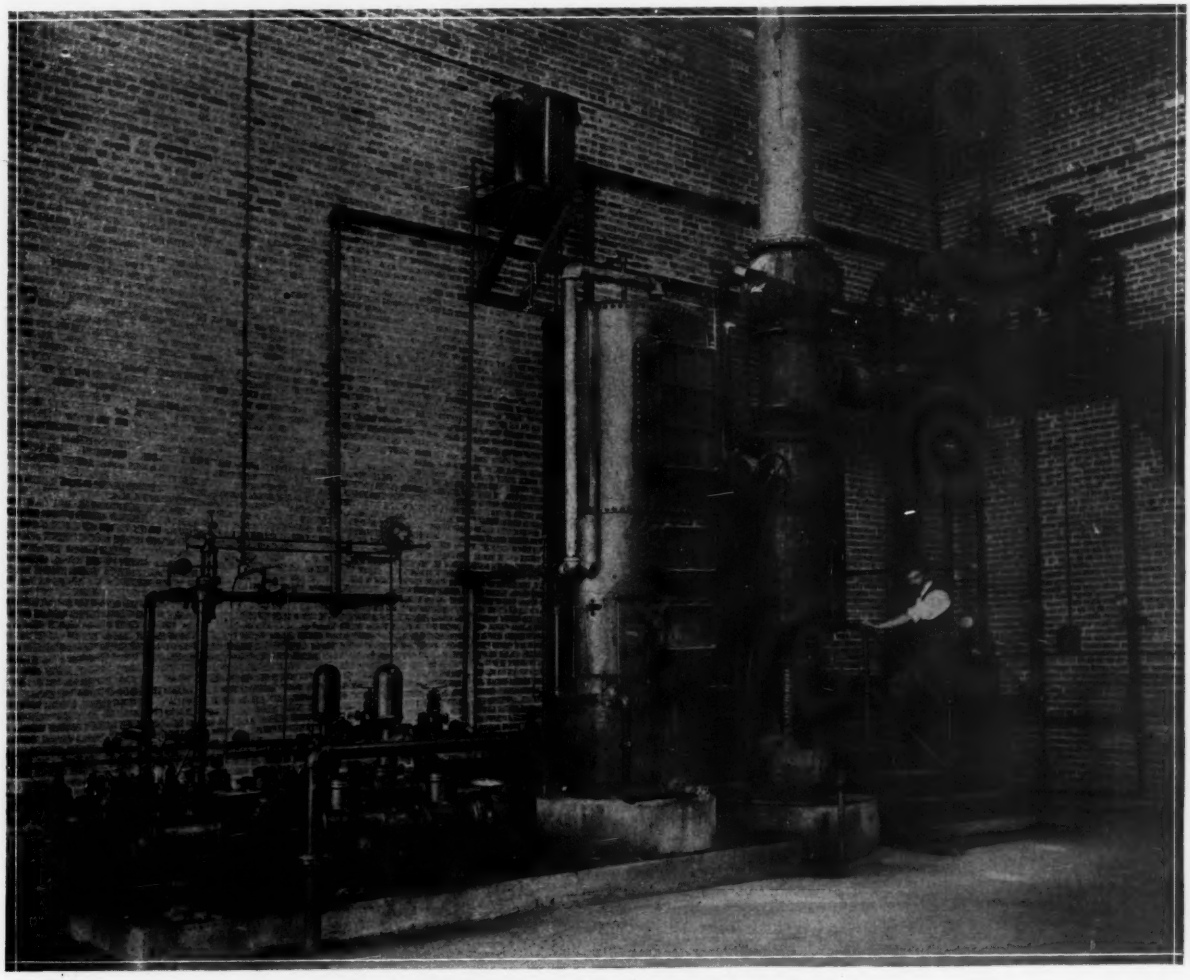


FIG. 10. OIL SEPARATOR, FEED WATER HEATER AND FEED PUMPS

All the water used for industrial purposes throughout the factory is piped to a 50,000-gal. reservoir conveniently located near the center of the factory, the bottom of which is 4 ft. above the engine room basement floor. In the engine room basement is located a duplex 6 by 5¾ by 6 in. Epping-Carpenter receiver pump of the packed plunger type, this receiver taking

the returns from several dozen steam traps throughout the factory and discharging into the 1000-gal. tank overhead where the condensation eventually returns to the boiler by way of the heater and feed pumps.

Leading into the receiver of this pump, is a 4-in. pipe connecting with the 50,000-gal. reservoir in which is a 4-in. balanced valve controlled by the height of the water in the overhead tank. In this way, just enough water is taken from the reservoir for the make up, and always leaves a reserve of about 1000 gal. of water on hand. The receiver pump can readily be changed to discharge directly to the heater, taking water direct from the reservoir.

FIG. 11. EXHAUST HEAD AND WHISTLES

Water from this reservoir is pumped to a 40,000-gal. tank on the roof where it is used over again, this tank is also connected to the heater. Should all these fail, the water level in the heater will fall about 8 in. opening a 2-in. supply from the city mains.

These various devices are so simple and effective that it is next to impossible to shut down the plant. Its effectiveness was illustrated recently by a break in the city main near the works which shut off all water for about 10 hr., yet the factory ran as usual with no trouble whatever.

Just off the main basement is the air room, wherein is located the Knowles vacuum pump above referred to and also a Blaisdell air compressor which is controlled by an automatic pressure regulator conveniently located in the engine room. This compressor supplies air for inflating tires and also for a number of pneumatic hoists located throughout the plant. The cooling water from this compressor passes directly to the receiver pump.

Comfort as Well as Economy

NO pains have been spared to make the plant not only the most modern possible, as far as equipment is concerned, but the plant was so designed, arranged and equipped, as to make work in it a pleasure. The engine room contains 30 windows and a skylight 9 by 38 ft., in which are located 2 large Burt ventilators. The boiler room contains 22 windows and a skylight 9 by 28 ft. in which are located 4 Burt ventilators and 8 traps.

The boiler room floor is of concrete as is also the basement floor under the engine room, these floors draining to convenient catch basins which permit frequent and thorough cleaning. In one corner of the basement is located the toilet, wash and bath-rooms, hot and cold-water being supplied for the wash bowls and baths, the hot water running by gravity direct from the reservoirs in the feed water heater under a head of about 4 lb.

The engine room floor is of reinforced concrete covered with hard maple, filled and varnished. Since the accompanying photographs were taken, however, the effectiveness of the plant as a whole, has been enhanced by several additional refinements, among which are pipe covering for all the steam lines, a hot water meter in the main between the pumps and the boilers, recording steam gages and electrical instruments, C O_2 recorders, etc.

Surrounding the power house are tastefully arranged, spacious lawns, flower beds, and vines and the entire plant as a whole, savors more of a well kept residence in a refined section of the city than of a power house of a modern manufacturing establishment.

Plans for the entire powerhouse equipment, including engine, boiler, heater, pumps, etc., and the foundations for them were drawn by the chief engineer of the Kelly-Racine Rubber Co., Geo. H. Wallace, and not

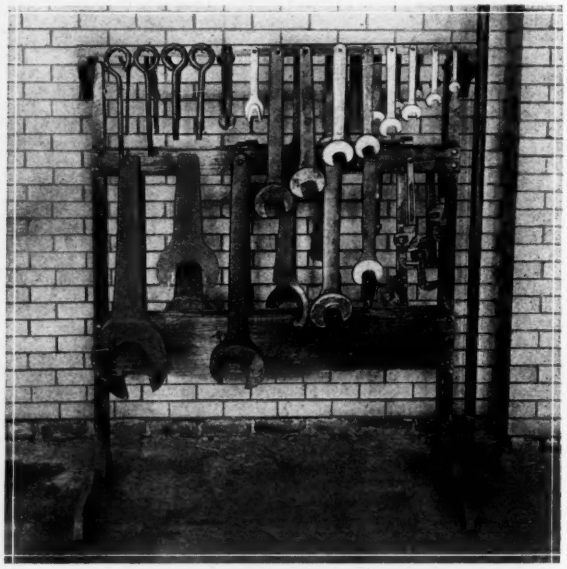


FIG. 12. ENGINEER'S WRENCH RACK

only was it all planned by him, but it was installed under his personal supervision.

Mr. Wallace also prepared plans for the foundations of all the machinery in the mill room and personally laid them out, which but goes to prove that an engineer can dispense with the extra expense of a mechanical engineer if an opportunity is but given to do so. The plans of the factory proper and the economical general arangement of the machinery were prepared under the personal supervision of Wm. H. Seward, general factory manager, who is perhaps one of the leading men in the rubber industry in this country.

FRICTION

FRIEND AND ENEMY; THE WHY, THE HOW AND HOW MUCH OF ITS ACTION; COMPASSING ITS DEFECT

FRICTION IS, AT THE same time, the bane and the blessing of the engineer. At every turn of a journal, with every motion of a lever, it eats up the energy for which human muscle has strained and good fuel has been burned. If neglected, hot bearings, scored cylinders, the wrecked engine, with its maiming, murderous fragments will result.

But without it, not a nut would hold to its bolt, belts and brakes would be useless, nothing could keep its position except on a dead level. So friction is necessary, but in moving bearings it is out of place, and the less of it the better.

Cause of Friction

TO get no friction, we should need a perfectly smooth surface, a thing which neither man nor nature has achieved. Even the smoothest seeming surface, when subjected to the microscope's revealing test proves to be a very mountain range of peaks and valleys, and

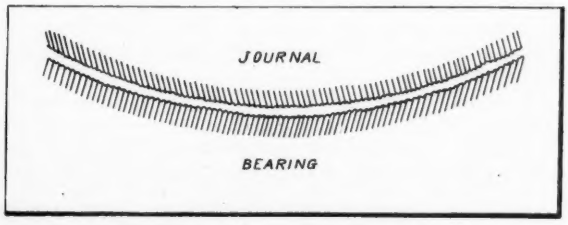


FIG. 1. CROSS SECTION OF SURFACES AS SHOWN BY MICROSCOPE.

these projection, interlocking, must be broken off or ride upon one another when there is sliding of one surface over another.

When standing for a time, the irregularities become more deeply engaged, so that starting friction is always greater than running friction. Also for surfaces that are rough or which are pressed together hard the friction will be greater than for those which are smooth or pressed lightly.

In the case of rolling friction, the force required is due more to the pulling of the projections of one surface out from the hollows of the other, like pulling

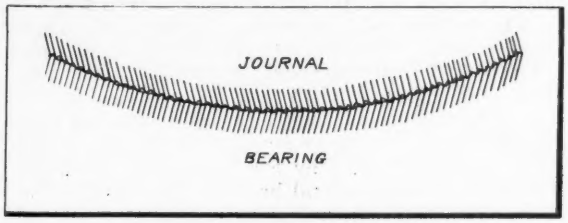


FIG. 2. INTERLOCKING OF PROJECTIONS ON SURFACES

a blunt stake out of the ground, than to riding one projection over another. This takes less force than for the sliding over process, hence a roller or ball bearing reduces the friction greatly over that of a plain bearing.

Fluid friction differs from solid because the particles of a fluid have no fixed position and pass by each other readily. The friction depends, therefore, only on stickiness or "viscosity" and not at all on the pressure in the liquid.

Two Remedies

EXPERIENCE has developed methods of reducing friction; to reduce the hills by polishing or to fill up the hollows by means of a solid lubricant such as graphite or soapstone; and to substitute liquid for solid

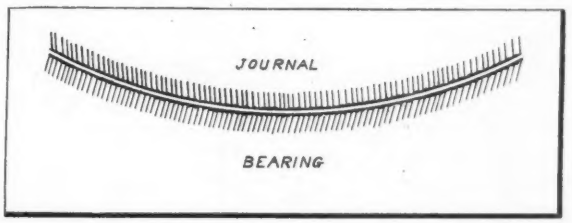


FIG. 3. FILLING UP OF HOLLOWS BY SOLID LUBRICANT

friction by using a liquid film to hold the surfaces apart.

In any case the energy wasted depends on the amount of friction and on the speed of running, and as the amount of friction in a lubricated bearing is dependent on the viscosity of the lubricant, it is well to use as thin a fluid or one with as little stickiness as possible. There is trouble, of course, if the fluid is so thin that the pressure breaks the film of lubricant and the 2 solid surfaces rub on one another; so for a bearing carrying a high pressure per square inch of projected area of journal, the lubricant must be heavy, thick and viscous; while for light pressures, the oil may be very thin.

It is more important to avoid the contact of the bearing surfaces or "seizing" than to save a little on friction, hence it is better to have the lubricant a little too thick than a little too thin.

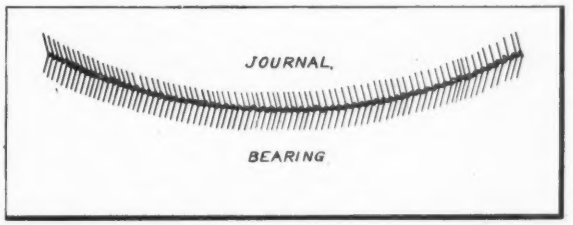


FIG. 4. INTERPOSITION OF A FLUID FILM ON BEARING

Good Lubrication

FOR good working a bearing must be so lubricated that the surfaces are kept apart; the fluid must not fry or gum; it must not eat the bearings or journals; it must not become inoperative by thinning too much with cold; it must not be easily ignited; it must contain no gritty matter which might cause cutting. In addition, in order to reduce friction, the transmission should be arranged with the end in view of keeping the pressure on bearings as light as possible.

The coefficient of friction of any material is the ratio of the force required to produce motion to the pressure.

Laws of Friction

FRICTION between solids acts according to laws that have been carefully proved. They are as follows: The force to overcome friction will depend on the total pressure between surfaces, but not on the areas of contact so long as the surfaces are not forced out of shape by the pressure on them. This is shown by Davis in experimental form as in Fig. 5. Liability to heating and cutting increases, however, with decrease of the area of contact.

Energy used up in friction increases with speed of running except at very low speeds where the friction approaches that of starting; at such speed the friction is greater than at high speeds owing to the deeper meshing of surfaces., This meshing also produces

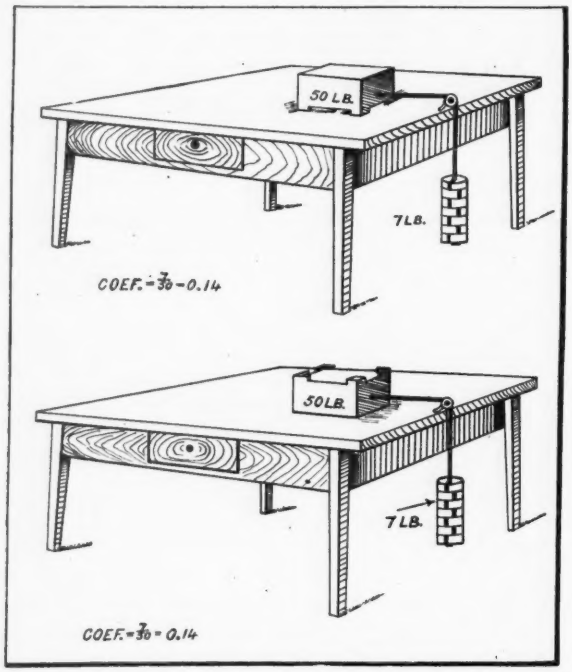


FIG. 5. DAVIS' ILLUSTRATION OF THE FIRST LAW OF FRICTION AND THE COEFFICIENT

greater friction between rough surfaces than between smooth, and between soft materials than between hard.

As an example of the amount of loss from friction, tests of line shafting have shown from 20 to 50 per cent of the engine power taken up in belts and bearings; in an engine that is poorly built or badly cared for the friction may waste 15 to 20 per cent of the indicated horsepower; a pipe threading machine has been known to eat up 20 to 50 per cent of the power required to operate it in friction of the parts; a big engine lathe turning slowly used 2.1 on friction and 6.38 hp. when cutting or 33 per cent in friction. These figures, and especially the wide variation in some instances, emphasize the need of giving careful attention to proper lubrication and lubricants, in order to avoid excessive waste of energy in your plant.

INCREASE IN VACUUM will reduce steam consumption, as shown by W. H. Wallis in Engineering, as follows, the reduction being by increase from 25 in. vacuum: For a Bellis engine at 28 in., 2 per cent; Weighton engine at 28.5 in. 5 per cent; compound reaction turbine at 27 in., 7.5 per cent; at 28 in., 12 per cent; at 28.6 in., 16 per cent.

THE WHY OF THE DIFFERENT LUBRICANTS

Using the Right Oil in the Right Place is the Secret of Getting Right Results. We Should Know Those Qualities Which a Lubricant Must Have To Successfully Meet its Purpose.

IN ORDINARY lubrication the conditions producing the greatest differences are the nature and quality of the lubricant, the nature and condition the wearing surfaces, and of prime importance, the speed pressure and temperature of the surfaces to be lubricated. Until recent years, or previous to the discovery of petroleum, the only known lubricants were the few animal and vegetable oils, and these were so nearly alike under ordinary conditions that the subject of lubrication received little or no attention. But with the refining of crude petroleum and the many derivatives obtainable, lubrication has developed into an important factor in the modern machine world, and there are to-day, types of machines which owe their development in a great part to the possibilities of lubrication inherent in this mineral product.

Qualities of a Good Lubricant.

IN general, a good lubricant must combine the following characteristics:

It must have the ability to keep the 2 rubbing surfaces between which it is interposed from coming in contact.

It must be as free flowing as possible consistent with the preceding requirement.

It must offer as little friction as possible and have a maximum capacity for receiving, storing, and transmitting heat.

There should be no guming, or tendency to decompose when exposed to the air.

Acidity, or any property detrimental to metals must be absent.

Evaporation or decomposition must not take place except at high temperatures, and the lubricant must not congeal except at a very low point.

Recalling the wide range of conditions under which lubrication must take place, it is readily seen that no one lubricant could combine all these qualities in a superlative degree. It has, therefore, been the effort to produce a lubricant to meet best a given condition, high in those qualities most essential, and low in those not essential.

The Three Classes

DEVELOPMENT of lubricants has taken place in 3 classes, the fluid, the grease, and the solid. In each the wide range from which to choose has made it possible to find a lubricant properly suited to the work in hand. The fluidity of the fluids decreases from the sperm, rape-seed, and highly refined petroleum oils, to the thick, heavy cylinder stocks; the greases comprise those which will melt by the warmth of the hand to those that require several hundred degrees of temperature to melt them; the solids include graphite, mica, and composition metals. The making of these various lubricants need not here be shown since it is being discussed in another article in Practical Engineer.

Animal and vegetable oils which were once the only source of lubricants, have the undesirable features that they will eventually decompose, become gummy, and retard the speed of any machine to which they may be applied. When butter or lard becomes rancid

or olive-oil becomes thick, we have a very good example of the deterioration of these oils. The decomposition is the result of oxidization, that is, the substance has the ability to absorb oxygen from the atmosphere, forming new compounds within itself, and sometimes, if the absorption of oxygen be sufficiently rapid, spontaneous combustion takes place. Stearic acid, which has a corrosive effect on metals is generally one of the products of decomposition. Although undesirable in a general sense, there are some features about animal and vegetable oils which make them valuable when compounded with mineral oil, for uses which will be described later.

Factors that Determine the Quality

IT was stated that a lubricant must be able to keep the rubbing surfaces apart. This depends on what is commonly called the body of the oil, by which is meant its ability to cling to a surface, combined with its ability to resist the separation of its own particles from each other. If we rub a small amount of an oil between the fingers, the "feel" of it gives a good idea of the body; or, fill a small bottle with some oil, leaving a little air space in the neck, invert the bottle and notice whether the bubble rises rapidly, or takes a long time in coming to the surface. The slower it rises the greater is the body. The measure of this latter characteristic is termed its viscosity, and is one of the chief factors in determining the quality and suitability of a lubricant.

Viscosity is determined by the time, in seconds, multiplied by 2, consumed for 60 cubic centimeters of the oil at a given temperature in passing through a certain small tube. For lubricants intended to be used at ordinary temperatures, the viscosity is taken at 70 deg. F., for cylinder and valve oil at 212 deg. F. It would be well perhaps, to mention here that 2 oils may have the same viscosity at, say 70 deg. F., yet differ considerably at other temperatures. Heat lowers the viscosity.

When a mineral oil is heated it begins to give off a vapor, at a certain temperature, depending on the nature of the oil. This vapor will take fire in little flashes when a small flame is held over the heated oil. This temperature is called the flash point. A further increase in temperature establishes a point where the oil itself takes fire and burns. This is known as the fire test.

An oil, such as kerosene, has a low flash and fire test, while heavy oils from which the most volatile matter has been distilled off, are high in these qualities.

The point, or temperature at which an oil becomes flaky and begins to congeal is termed the cold test.

Gravity for oils lighter than water is reckoned by the Beaume (B') scale, which has a value of 10 corresponding to unity in the standard scale. As the gravity decreases the Beaume indications increase, that is, an oil of 50 deg. Beaume is heavier than one of 60 deg.

For a more complete description of the method of determining the specific gravity, the reader is referred to page 241 of the May issue of Practical Engineer, where one of a series of articles on the production of lubricating oils will be found. How these qualities influence the selection of a lubricant will now be considered.

Influence of Operating Conditions

IN machine practice, lubrication must meet one of 4 general conditions of operation; high speed and light load; high speed and heavy load; low speed and light load; low speed and heavy load. Although only speed and load have been mentioned it must not be overlooked that we are dealing primarily with friction and the consequent heating which means a rise in temperature, an influencing factor.

The first condition includes the very light, high speed machinery, used in the manufacture of various articles, in delicate grinding, textile industries, etc., where high speed and uninterrupted operation are the paramount issues. The maintenance of high speed with a minimum of energy, demands a lubricant that is limpid and very free flowing, but must have sufficient viscosity to prevent the wearing surfaces from coming in contact with each other. Any unnecessary amount of viscosity will have a retarding effect, and require an increased amount of power. The cold test must be low, or otherwise in cold weather, unless the machine were operating in a very warm room, the oil would have a tendency to congeal, producing the same results as the too viscid oil.

If its flash point is very low, the heat of running will cause inflammable vapors to be driven off, leaving the remaining oil too viscid, thereby increasing the frictional load, and, incidentally the lubrication expense. It must be free from any substance tending to oxidize or thicken it. The qualities of some vegetable and animal oils makes them still useful in some light work, and sperm, grape, and cottonseed oils are sometimes to be recommended.

A characteristic example under this head is the spindle used in textile mills. It requires on an average 0.01 hp. for each spindle with the speed at from 8,000 to 12,000 r.p.m. There are 160 to 224 spindles to a frame, and, supposing 100 frames in a mill, with a total horsepower of 160 to 240, it becomes quite apparent what an important part lubrication plays in this industry.

The specifications for a highly refined petroleum oil, which has proved satisfactory for this service, are as follows: Gravity, 32 to 34 deg. B'; viscosity, 140 to 160; cold test, 25 deg. F., and an evaporation test not to exceed 4 to 5 per cent when heated 12 hours at 150 deg. F. In the engine room, the mechanism of the ordinary fly-ball governor, revolving at a high speed, offers another good example, but its lubrication may be effected with the light engine oil, since a few per cent greater friction in its operation is too small to notice.

In the second case the general requirements of the first apply, except that as the load or pressure increases the tendency to squeeze out the oil from between the bearings increases, thus making it essential that the lubricant possess a greater degree of viscosity and a marked ability to carry off the heat.

Accomplishment of good lubrication with high speed and heavy load is well shown in the self-oiled bearings of generators designed for this condition. While a small amount of good oil applied constantly to a bearing in good condition will prevent heating, yet in general service such conditions are not always found, and experience has shown that by flooding the bearings, or self-oiling, the temperature is kept at a minimum and the coefficient of friction is reduced. The rings or chains dip into the reservoir of oil on their lower side, carrying it up to the top of the bearing, where it is distributed along the length of the bearing and flows between the bearing and the journal.

During its course between the wearing surfaces, it absorbs what frictional heat there may be generated, then drains back into the reservoir, giving up its heat to the larger quantity of oil. Compared to the amount of oil that at any time is on the bearing, the amount in

the reservoir is very great, and with the large radiating area which it provides, it is able to take up and pass off the frictional heat at a rate which prevents the bearing from showing any appreciable rise in temperature. A lubricant for this purpose should have average values as follows: gravity, 28 deg. B'.; flash point, 400 deg. F.; viscosity 180. The cross-head and bearings of high speed engines, are other good examples in this class.

In the instances which would be designated as low speed and light pressure, the lubricating conditions are the most favorable, and the most easily met. If power consumption were of first consideration, a good grade of mineral oil with a low viscosity would be best to use, otherwise a low melting point grease, free from grit, dirt or a tendency to decompose, would be economical. Ordinary vaseline or greases of a similar consistency are much used in this class of work.

The Use of Greases

GREASES do not lubricate until sufficient heat has been generated to melt them, and their consistency or fluidity, after melting, depends on the temperature. If a grease of low melting point were to be used where the temperature and pressure were high, it is evident that it would soon become too thin thereby losing its body, and would then have little ability to maintain itself in a substantial, unbroken film between the rubbing surfaces. This, then, gives the clue as to the adaptability of a grease for any particular purpose.

For slow speed and heavy pressure, oils ought not to be used except in some of the heaviest, viscid stocks, the greases and solid lubricants proving more serviceable. Greases for such work possess high melting points, which insures a quite viscid fluid when melting does occur, enabling it to remain properly between the rubbing surfaces. Also, the ease of application and cleanliness, often recommend the use of a grease.

The rolls of a steel mill present an excellent example of the use of a grease, for slow speed and high pressure. The rolls are solid, and on the ends are journals or necks, almost as large as the roll itself. In making plates or sheets the metal is run through the mills at a white heat, and is reduced about 3 in. at each pass. Necessarily, since no water may be used on the bearings, they become very hot, demanding a grease, very adhesive and of high melting point. "Hot-neck" grease, which has been developed for this purpose, is so dense that it must be heated over a fire before it can be used, and is applied while hot.

Talc, soapstone, lime, or graphite, combined with heavy petroleum residuum and animal greases, are the ordinary constituents of this lubricant. For those rolls on which cold water may be run, a somewhat less dense grease containing, generally, suet, tallow, and sometimes petroleum greases, are used. They are wrapped in a piece of burlap and tied around the neck, allowing the heat to melt sufficient for lubrication. The little cloth-covered lumps of paraffin, with which the housewife cleans her sad irons, is a homely, but good illustration of this latter principle.

In the last few years there have appeared on the market a number of greases intended to supercede the use of oil in various cases, and if properly compounded, are certain to be more or less successful for many purposes; for, with a bearing, in every condition from very good to very bad, a wide latitude must be allowed the engineer in his selection of a lubricant. Often a bearing is found in such a shape that a grease must be used although an oil had been intended.

All the solid lubricants exclusive of the so-called anti-friction metals, are compounds of graphite, soapstone, talc, or a substance of oily or saponacious quality. With slow speeds and very heavy pressures they find their greatest application, and are, especially useful where metal is made to rub on wood.

Lubricating the Steam Cylinder

IN steam cylinder lubrication we are confronted with new conditions: The presence of water, and very high temperature. Mineral oil of a high viscosity is preeminently the oil for this purpose, recalling the fact that it will stand a high temperature without disintergrating or evaporating. But a mineral oil will not mix with water, nor adhere to a metal surface in the presence of water. Due to condensation and wet steam there is always water to greater or less degree passing the valve and cylinder, and therefore, in using a pure mineral oil there would be great danger of the lubricant floating on the water, and passing through the valve or cylinder without performing its function. A vegetable or animal oil, when subjected to high temperature existing in steam cylinders, will form an emulsion or milky substance with the water, and this emulsion has the property of so preparing the metal surfaces that the mineral oil will adhere and properly lubricate the cylinders. All good steam cylinder oils are necessarily mineral oils of high viscosity and flash point, compounded with a small amount of one or more animal or vegetable oils to meet this contingency.

The Combustion Engine

THE advent of the gas and gasoline engine has made it necessary to develop an oil for its own particular requirements. The constant explosion of the gas raises the interior walls of the cylinder to a very high temperature, notwithstanding the fact that a water jacket is provided to carry away the heat. The temperature in the firing end is about 1800 to 2000 deg. F., at the moment of ignition. No oil can withstand this temperature; it is necessary then, to have an oil that will not burn readily and that will spread quickly and easily keeping the metal surfaces apart, and when it does burn, no deposit or residue must be left. This latter effect is termed carbonizing, which is detrimental to the operation of the engine, the residue, or carbon, filling up the cylinder and consequently reducing its volume, and by collecting on the ignition points prevents the passage of the electric spark.

Oil used for combustion engines has a flash point of about 500 deg. F., and a viscosity about 175, or as low as possible, consistent with the flash point. The chief factor in reducing the carbon deposit is filtering, which is done by passing the oil through very fine Fuller's earth, thereby removing the free carbon or coke which passes over with the oil vapor during its distillation. This coke is seldom discernable to the eye, but its removal is shown by the color becoming constantly lighter as the oil is filtered and refiltered.

The Air Compressor

COMPRESSION of air with its attending rise in temperature, brings into existence conditions peculiar to the air compressor. In some single stage machines taking air at 60 deg. F. and compressing it to 100 lb. pressure, the temperature often reaches over 400 deg. with the cylinders water-jacketed. In the 2 or more stage compressors, due to the recooling between the cylinders, the temperature is somewhere between 200 and 275 deg., depending on local conditions.

In the compressor cylinder the air is hot and dry, giving an oil favorable opportunity to adhere to the

surfaces. This fact allows the use of a less quantity of lubricant than is necessary in a steam cylinder of equal size where the water tends to wash out a considerable portion of the oil, but the intensity of this dry heat necessitates the use of a lubricant of such nature that it will not easily volatilize, or form a coating of burnt oil or carbon around the valve.

If the flash point is too low the oil, on reaching the highly heated interior, volatilizes and passes off with the air, affording little lubrication to the wearing surfaces; if compounded with animal or vegetable oils, or if it is too dense, it will adhere to the discharge valves, and from subjection to the dry heat will in time form a hard, brittle crust or layer of carbon, seriously injuring the valves, and often chocking them up. It has been ascertained that if the temperature reaches 300 to 400 deg. F., a pure petroleum oil with a medium viscosity, and a flash point between 500 and 550 deg. F. gives best results.

Complaints concerning air compressor lubrication come principally from operators of small, single stage machines, which at times are driven much beyond their capacity, raising the temperature considerably beyond 400 deg. The attendant generally begins to use more oil, and this excess gathering around the valves and burning is the source of the trouble.

APPROXIMATE LIMITS TO BE OBSERVED IN SELECTING A LUBRICANT

SERVICE	GRAVITY BAUME	VISCOSITY AT 70° F	FLASH POINT DEG. F.	COLOR
HIGH SPEED LIGHT LOAD	32 — 40	130 — 160	250	PALE YELLOW TO LIGHT AMBER
HIGH SPEED HEAVY LOAD	24 — 35	160 — 225	375 OR MORE	AMBER TO RED
LOW SPEED LIGHT LOAD	25 — 30	140 — 200	250 — 350	LIGHT RED TO DARK RED
THIN OR EASILY MELTED GREASES				
LOW SPEED HEAVY LOAD	20 — 30	200 — 300	300	VERY DARK RED OR GREEN
HEAVIER GREASES OR SOLID LUBRICANTS				
STEAM ENGINE CYLINDER	25	180 — 200	500 — 650	VERY DARK RED OR GREEN
COMBUSTION ENGINE CYLINDER	30 — 35	175 — 200	500 — 600	AMBER OR LIGHT RED
AIR COMP. CYLINDER	25 — 30	200 OR MORE	400 — 530	AMBER

As has been suggested, the subject of proper lubrication in general practice cannot be governed by any single set of rules, for with the wearing surfaces to be found in any stage of perfection, or rather imperfection, it can be the endeavor only to show the qualities which affect lubrication, then allow the engineer to study for himself what will best meet his own needs. To emphasize the extent to which lubrication is effected by the conditions of the bearings, the following instances serves well: Of 2 friction-testing machines in the same labratory, the bearing of one had become somewhat rusty through a period of disuse. When again required the bearing was cleaned and smoothed down with rouge, but it was found that the 2 machines now differed in their results by several per cent, although previously their results had been almost identical. The reason lies in the fact that the bearing had not been returned to its former condition of smoothness, notwithstanding the effort to do so, and consequently required greater lubrication.

MATERIALS USED FOR LUBRICANTS

FIRST comes water. Not because it is best, but because it is most common and cheapest. Evidently it is entirely unsuitable for heavy pressures unless the bearing can be made water tight and the water put under pressure. But for certain operations, such as light running, high speed journals, wood step bearings, propeller shaft thrust bearings, turning metals, etc., water polishing is effective, and as an assistant lubricant, to cool overheated bearings water is the best possible medium. Water polished surfaces rust easily, however, if left exposed to moisture.

Next in density come the light oils and thin greases, vegetable, animal and mineral. These are better than water because the particles stick to each other, and

FIG. 1. FLAKE GRAPHITE MAGNIFIED; THE FINE NEEDLE SHOWS COMPARATIVE SIZE

also to the surfaces of the bearings, thus helping to keep the lubricating film unbroken.

Among the vegetable oils are castor oil, palm oil and olive oil, all suitable for only the lightest of bearings. These become thick and gummy on exposure to the air, and are costly, hence they are little used for lubrication.

Animal lubricants include lard, tallow, neatsfoot and sperm oils. Unless carefully purified they are

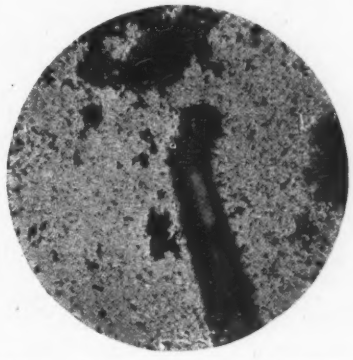


FIG. 2. GRAINS AND CLUSTERS OF POWDERED GRAPHITE

likely to contain animal acids and will become rancid after standing. Nevertheless, when carefully prepared and compounded with mineral oils, they are most important mediums. Tallow is little used except for the roughest of bearings, and is thinned by the heating of the bearing. Kidney tallow, which is free from acid, forms a valuable constituent of greases.

Lard oil, because of its uniformity is often taken as a standard of comparison in making tests of lubricants.

Most important of the fluid lubricants are, however, the petroleum products which by distillation and combination can be obtained in form suitable for any purpose. These range from kerosene which in tests made by Dean Goss showed good results up to pressure of 50 lb. per sq. in. of bearing area and a coefficient of friction of 0.00547 up to heavy crude oils and greases which will carry 625 lb. per sq. in. and have a coefficient of 0.01. Kerosene is not, of course, classed as a lubricant, as its film is too easily broken.

FIG. 3. OUTCROP OF GRAPHITE VEIN IN MEXICAN MINES

Engine and machine oils run from 500 to 550 deg. fire test and cylinder stocks from 550 to 700 deg. For gas engine cylinders the fire test is 400 to 480 deg. or over and viscosity high and should be free from carbon, i. e., must be of a light color.

Solid lubricants used are graphite, mica, soapstone, and soap. The first is the most common, the second and third being of value for certain purposes and in combination, and the last being used as a constituent of some greases.

Graphite is used in 2 forms, the amorphous or powder, either natural or artificial and the flake. The difference between the 2 forms is shown by the cuts Figs. 1 and 2 microphotographs of the flake and powdered, respectively. The chief sources of the natural graphite are from fibrous mines in Ceylon, Europe, and Asia, and in this continent for flake graphite at Ticonderoga, N. Y., and for powdered in Sonora, Mex. Artificial graphite is made at Niagara Falls, N. Y., in large quantities.

For use as a lubricant it is important that any solid should be free from grit or hard particles that can scratch the bearing surfaces and careful test should be made of this point.

While solid lubricants are used for some purposes, as a rule they are combined with oils or greases to give greater smoothness to the bearing surfaces, the oil or grease film being maintained between those surfaces. The advantages of such use are stated in other articles in this issue.

Beds of graphite are found in about the same formation as are veins of coal. Veins in the Mexican mine run up to 9 ft. thick and 30 ft. wide, and are taken out by pick and shovel, taken to the surface dried in the sun and then shipped in bulk to factories where it is ground and separated by means of air flotation and bolting through fine mesh screens. The best grades, mixed with finely ground clay in proportions to give different grades of hardness are used for lead pencils and foundry facings. In an emergency, a soft lead from a pencil ground fine has helped out on a troublesome bearing.

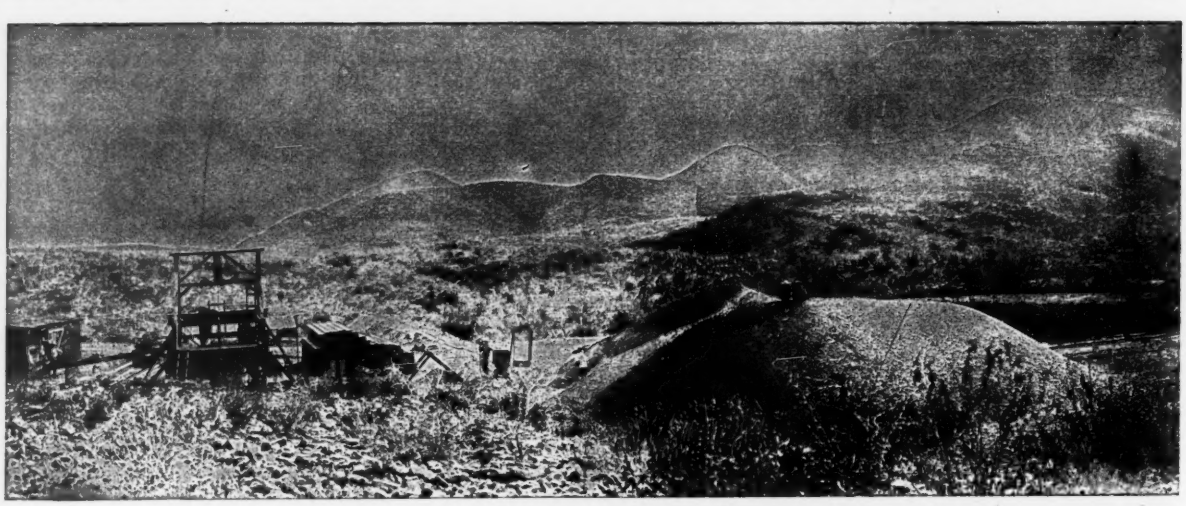


FIG. 4. PILES OF NATURAL GRAPHITE READY FOR SHIPMENT

For power work, the lightest oil is usually classed as dynamo oil and runs about 470 deg. F. fire test and 220 viscosity to 425 deg. fire test and 150 viscosity. The higher test oils are the safer on the principle already stated, that too thick is better than too thin. Air compressor oils run about the same tests as for dynamos or a little higher, say 480 deg. fire test and 210 viscosity.

THE ART OF USING oil consists of choosing one that best suits each place, and applying it in a way that best suits its place.—Thurston.

SOURCES AND METHODS OF PRODUCTION OF LUBRICATING OILS

PROPERTIES AND METHODS OF TESTING

By W. A. Converse*

LUBRICATING oils, kerosenes, etc., at some temperatures, give off an inflammable vapor. The temperature at which an oil will give off a sufficient amount of vapor to form a mildly explosive or inflammable compound or mixture with the air, which burns upon the application of a flame, is known as the flash point. The temperature of the oil being raised, a greater volume of vapor is given off and the production of the vapor being sufficiently rapid to maintain a continuous flame, the oil takes fire and burns; the temperature at which this takes place is the burning point, or is more commonly referred to as the fire test.

The determination of the flash point is essential, as it furnishes information as to the amount of lighter oils present; further, oils having too low a flash point are dangerous to use.

The determination of the burning point is of even greater importance, as it is the point at which the oil begins to decompose and rapidly loses its lubricating properties and value. There are 2 kinds of apparatus used for the determination of the flash and burning points of oils, viz., open and closed cups, the former being used for lubricating oils, and the latter for kerosene, naphthas, etc.

FIG. 1. OPEN CUP USED FOR DETERMINING FLASH POINT

As we are not here especially interested in the properties of kerosenes, they will not be considered further.

In making the fire test, the cup contained in the support of body of the open cup is filled with the oil to be tested, within approximately ½ in. of the top. The thermometer is suspended from the support at the side so as to bring the mercury bulb as near the center of the body of oil as possible. Heat is then applied and the temperature raised until the 200 deg. F. (for engine oils) or 300 deg. F. (for cylinder oils) mark is reached.

The heating is then sufficiently controlled to maintain a uniform rise in temperature of the oil, of not less than 8 deg. nor more than 12 deg. per minute. At every 5 deg. rise in the temperature of the oil, as shown by the thermometer, a small gas flame or burning taper, giving a flame about ¼ in. long, is passed gradually forward and backward, approximately ½ in. above the surface of the oil. When a sufficient amount of vapor is generated, it will burn with instantaneous flash. The temperature at which this takes place is recorded as the flash point of the oil.

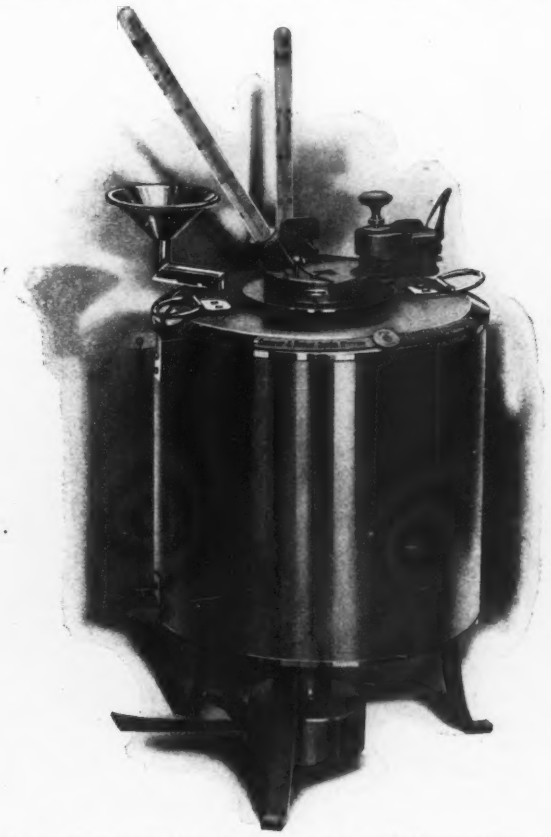


FIG. 2. THE ABEL OR CLOSED CUP FOR DETERMINING FLASH POINT

The heating is continued, and the temperature increased at the same rate; the flame is passed over the surface at every 5 deg. rise, as before, up to a point where the oil takes fire and continues to burn until extinguished by the operator. The temperature at which this occurs is recorded as the burning point.

Viscosity

THE term viscosity implies internal friction of a liquid. Therefore, the determination of the viscosity of an oil is the comparative measurement of its

*Chemical Director Dearborn Drug & Chemical Works.

internal friction. Preceding the introduction of the products of petroleum as lubricants, the question of viscosity did not interest oil consumers or producers, as, up to this time, comparatively few animal or vegetable fats or oils were available, and the viscosity of these varied but little at the temperature under which they were to be used.

All oils exhibit viscosity, but in widely varying degrees. In the hands of those accustomed to handling oils, a comparatively rough idea of the viscosity of an oil may be obtained by shaking it in a bottle, or by inverting the bottle, so as to entrap an air bubble at the lower end, noting its rise through the body of the oil; but this is not sufficiently accurate to avail the operator much, consequently it is necessary that a properly constructed viscosimeter be employed.

Many forms of apparatus for this purpose have been produced, but only 2 are in general use, viz., the Saybolt and the Tagliabue. The former not being obtainable in the open market, the latter is almost uni-

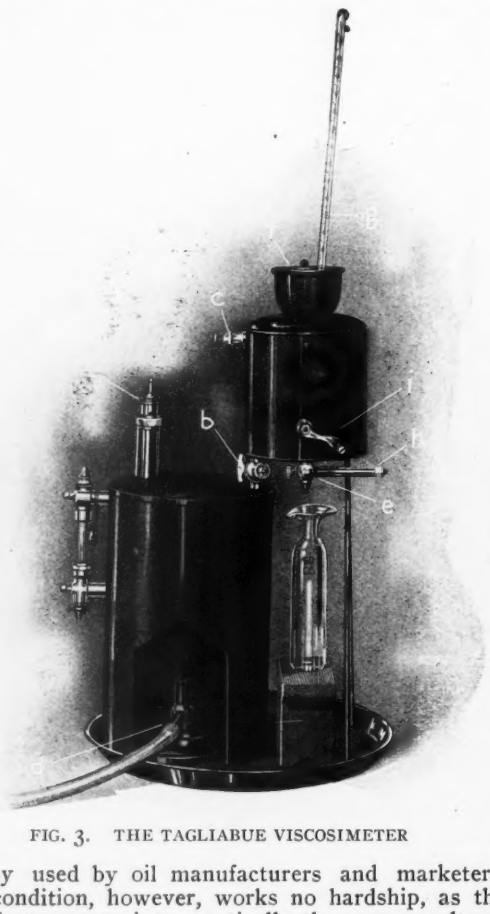


FIG. 3. THE TAGLIABUE VISCOSIMETER

versally used by oil manufacturers and marketers. This condition, however, works no hardship, as the latter instrument gives practically the same results as the former. This being the case, only the Tagliabue instrument will be considered.

The viscosity of engine and dynamo oil is taken at 70 deg. F., and cylinder and valve oils at 212 deg. F.

To test the viscosity of oils at 212 deg. F., pour water into boiler through opening a, after unscrewing safety valve until the water gage shows that the boiler is full. See that stop-cock b is open, making direct connection between boiler and upper vessel which surrounds the receptacle in which the oil to be tested is placed. Place a wire holder for the thermometer in set nut c and suspend thermometer so that the bulb of thermometer will be about ¼ in. from the bottom of oil bath. Then after carefully straining 80 c.c. of the oil to be tested, which of course must be warmed in the case of very heavy oils, pour it into oil bath. Place lamp or Bunsen burner d under boiler; screw steel nipple marked 212 onto stop-cock e; the apparatus is now ready to use.

After steam is generated wait until the thermometer in the oil bath shows a temperature of 210½ or 211 deg.; then place the 60 c.c. test glass under the stop-cock e so that the stream of oil strikes the side of test glass, thereby preventing the formation of air bubbles; and when the thermometer indicates its highest point, open the faucet h simultaneously with the starting of a watch.

When the running oil reaches the 60 c.c. mark in the neck of the test glass the watch is instantly stopped, and the number of seconds noted. Then multiply the number of seconds by 2, and the result will be the viscosity of the oil. For example: If 60 c.c. of oil runs through in 101½ seconds the viscosity would be 203.

It is best to repeat the test until sufficient skill is attained by practice for uniform results. It is also

FIG. 4. THE THURSTON FRICTION MACHINE

necessary to keep the oil well stirred before making test in order to have the oil at a uniform temperature.

To test the viscosity of oils at 70 deg. F., screw the steel nipple marked 70 deg. on the faucet e, close stop-cock b, thereby closing communication between the boiler and upper vessel. Fill upper vessel through opening f, with water, as near a temperature of 70 deg. as possible, also having the oil to be tested, at the same temperature. Hang the thermometer in position, and after stirring the oil thoroughly, turn crank i, thoroughly agitating the water. Should the thermometer show a lower or higher temperature than 70 deg. add cold or warm water until the desired temperature is obtained. Then measure carefully 90 c.c. of oil to be tested, placing it in the machine, and when everything is ready, open stop-cock h, and start the watch at the same time, and allow 70 c.c. to pass through the nipple, and as soon as the test tube is filled to the 70 c.c. marked in the neck, turn off the

stop-cock and stop watch at the same moment. Should it take the 70 c.c. 96 seconds to run through the nipple, mulitply this by 2, and you will have the viscosity of the oil, which is 192.

Friction Tests

FIGURE 4 shows a view of a small Thurston friction machine, which constitutes an important part of the laboratory equipment of the Dearborn Drug & Chemical Works for the testing of oils and other lubricants. By the use of different sized pulleys on both the motor used to drive it and the machine itself, we are enabled to adjust the speed to practically any number of revolutions per minute. By manipulation of certain parts of the pendulum, we can adjust the pressure to from 25 to 200 lb. per sq. inch. Upon reference to the thermometer we can note, at any time, the temperature of the bearing.

The friction test constitutes essentially the determination of the amount of power necessary to overcome the resistance of an oil when applied to a bearing; the results of the test being given as the coefficient of the friction.

Except for scientific purposes, this machine is generally used in making comparative tests on 2 or more oils under consideration. The several oils being tested are run on the machine under exactly like conditions as regards pressure, speed, temperature of bearing at start, etc.; the oil is applied to the journal, through an oil well at the base of the thermometer, in sufficient quantity to prevent the temperature of the bearing from going above a certain point (usually 150 deg. F.); the oil used having been taken from a known quantity, the exact weight of which has been previously determined, it only remains to weigh back the unused portion in order to arrive at the quantity used in each case. This done, it becomes evident of which of the oils the greatest quantity was required.

The results can be tabulated on a percentage basis by selecting the best of the oils as a standard, assuming it to have a value of 100 per cent; from the quantity of the other oils used, their comparative values can be calculated. Through the test made in this manner, the actual friction reducing power is determined.

It is well understood that for each kind of bearing, speed, and load, only a comparatively few varieties of lubricants, of the many upon the market, will be found to give good results in practice. This creates the necessity of having a large number of oils, etc., in use at the same time, which is a decided disadvantage. Practical men in general prefer to use as few lubricants as possible to lubricate their machinery; the limitation must not, however, be carried to such an extent as to cause unnecessary loss of power and damage to rubbing surfaces; consequently, careful consideration must be given to the selection, and only the best products be chosen.

The advantage of careful selection of lubricants, according to the kind of bearing, its speed, etc., or, in case of steam cylinder lubricants, to the conditions under which they are to be used, is becoming more evident as time goes by.

The field of conditions under which lubricants are to be used is rapidly growing larger, therefore the conditions under which lubrication is to be effected are becoming correspondingly diverse. The time when the engineer could afford to use almost any lubricant placed upon the market has long since passed. While in the selection of lubricants the price is an important factor, there is no real economy in using cheap, unsuitable oils or greases.

USING GRAPHITE

Proportions to Mix With Lubricants to Cut Down Your Oil Consumption

AS explained at the outset, the use of graphite is to fill inequalities of surface, and only enough is needed to keep these inequalities filled. Dean Goss in a report on experiments made at Purdue University says that:

"By the presence of the graphite there is substituted for the frictional contact of the metals themselves, the frictional contact of 2 surfaces of compressed graphite, the frictional resistance of which is much less than that of the metal surfaces themselves. The evidence is that there is little or no movement between the graphitic surfaces, and there seems to be no train of individual particles the presence of which, if they existed, could be looked upon as the equivalent of the oil-film. Such dust-like particles may at times occur, but they do not long persist and their presence probably operates to increase, rather than to diminish the friction attending any motion of the parts. (Appendix VI).

"The best results with graphite are obtained when the graphitic coatings on journal and bearing are rubbed down to a fine, hard, well glazed finish. Two such surfaces are capable of being worked upon each other with a freedom of friction not equaled by that of any other solid material.

"A review of many different examples shows that wherever metallic surfaces have sliding contact under very light pressure, graphite alone may be accepted as a sufficient lubrication, and as altogether the most desirable one available.

"The action of graphite supplied to a bearing with oil or grease is in every way similar to that of graphite supplied alone. Once between the rubbing surfaces, it seeks to identfy itself with the metal of the bearing; to fill the pores of the metal; to build up low places; and to give to the surfaces in contact a superficial finish that cannot otherwise be had.

"By the use of graphite, water (under favorable conditions) may serve as a sufficient lubricant. It is entirely logical to assume that the preparation of the surfaces of a bearing may be so complete that not only limpid oils, but even water, may suffice for their lubrication. Confirmation of this comes from the engine room where, in the cylinders of steam engines, graphite has come to be extensively employed unmixed with other lubricants.

"In this service, the currents of steam, and films of moisture which extend themselves over the rubbing surfaces, serve as a sufficient vehicle for carrying the flake graphite forward and for distributing it over the surfaces to be lubricated, and the water of condensation serves as the intervening film with results which are as important as they have been satisfactory.

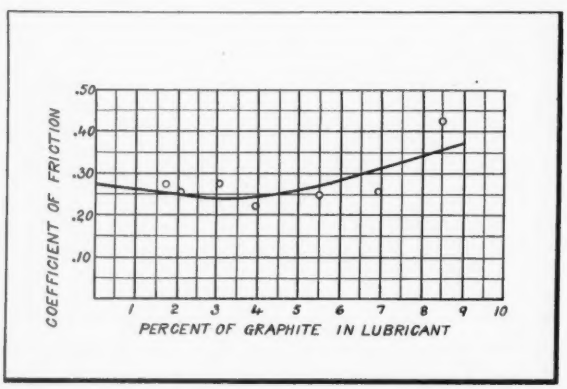
"Engines which have required large quantities of cylinder oil are now running on small quantities of graphite. Engines having valve seats and bore of cylinder cut, and which were going on from bad to worse in spite of the liberal use of high grade cylinder oils, are reported as giving no trouble and as having begun to improve as soon as flake graphite was substituted for the oil. Even in the cylinders of air compressors there is sufficient moisture to constitute the intervening film when the surfaces of the cylinders and pistons have been perfected by the presence of the graphite.

Tests made to determine the effect of mixing graphite with sperm oil showed on runs lasting from 60

to 110 min. and with 200 lb. per sq. in. pressure, that up to 4 per cent of graphite the coefficient of friction was lessened, and above that per cent it increased as shown by the accompanying curve.

In tests using graphite and a mixture ot graphite and water the coefficient of friction for graphite alone averaged 19.7 and with the mixture, really a thick paste, 14.5 per cent proving that the addition of a small amount of water was beneficial.

For compressed air cylinders the mixture of graphite with oil or with soapsuds has been found valuable.



VARIATION OF COEFFICIENT OF FRICTION WITH PER CENT OF GRAPHITE IN SPERM OIL

One maker of compressors recommends one tablespoonful of graphite to one quart of compressor oil and the use of ⅓ pint of the mixture every 24 hr. for a cylinder 16 by 18 in. The same proportion of graphite may be fed separately by admitting it with the air through the air inlet.

For rock drills, a teaspoonful of graphite to a pint of oil is advised, used in a regular oil can, and the oil can being well shaken before each application.

ACHESON GRAPHITE LUBRICANTS

GRAPHITE lubricants are put up in 3 forms by the International Acheson Graphite Co., these having the trade names of Gredag, Oildag, and Aquadag. Gredag is very finely ground, pure, gritless Acheson graphite, mixed with high grade grease. This lubricant is recommended for use in grease cups on heavy, medium, and light duty, on all classes of machinery including crushers and grinders, engine bearings, slides, cables, and so forth. Being a mixture of grease and graphite, temperature changes have little effect upon it, its consistency not being appreciably altered between the freezing point and 170 deg. F. Gredag is made in several grades and consistencies to meet all requirements, ranging from semi-fluid to medium.

Oildag is made by combining Acheson graphite and oil and is recommended for use in every case where lubricating oil is advisable. It is put up in condensed form in cans, containing sufficient to charge from 1 to 50 gal. of mineral oil.

Aquadag is a mixture of defloculated graphite and water and in this form the graphite remains suspended in the water. The graphite is mixed with water to serve as a carrier and is put up in the form of a paste for charging a specific quantity of water. This lubricant is a valuable aid in all kinds of metal turning and is a decided coolant for hot bearings.

FLAKE GRAPHITE AS A LUBRICANT

Dean Goss' Opinion As To Its Effect

FLAKE Graphite is of much interest to those who are seeking an answer to the lubricating question. Graphite is not a competing factor with oils and greases, but rather stimulates their lubricating value and its judicious use permits a less viscous lubricant being used, and this in itself is of much importance.

Graphite exists in both the amorphous and the flake form. The flake form of the thin, unctuous, Ticonderoga variety is superior for lubricating purposes, and there is always danger in using material which happens to be labelled "graphite," as there is as much difference in available lubricating qualities of various grades of graphite as there is in the different grades of lubricating oils.

No matter how well the bearing surfaces may be polished, examination under a microscope will show them like a relief map or a nutmeg grater. It is the high spots interlocking or rubbing over each other, and their gradual breaking down that cause friction and its accompanying wear. Thin flake graphite which settles readily in oil, attaches itself to the high spots where the flakes become pinned or fastened. Soon a tough, thin, veneer-like coating of the highest possible degree of smoothness is woven together, and instead of having metal to metal contact, when the oil film for any reason is broken, there is a graphite to graphite contact.

Scientific tests have proven that even with ball bearings, friction losses are greatly reduced and the load carrying capacity very greatly increased when the correct proportion of flake graphite is used. In this connection Prof. Goss, Dean of the College of Engineering, University of Illinois, says in part:

"A combination of graphite and lard oil makes up a lubricating mixture which, when applied to ball bearings, will accomplish everything which lard oil alone will do and which at the same time will give a lower frictional resistance of the bearing and permit a large increase in the load which it may be made to carry.

"An oil as light as kerosene, when intermixed with graphite, will be converted into an effective lubricant for ball bearings when operated under light or medium heavy pressure.

"Even so viscous a lubricant as vaseline will better perform a given service in the lubrication of ball bearings when supplemented by small amounts of graphite. The bearing to which the mixture is applied will work with less frictional resistance and will carry a heavier load than when vaseline alone is used.

"The admixture of graphite with either a liquid or viscous lubricant serves both to reduce the friction and to increase the possible load which a bearing thus lubricated can be made to carry."

The Joseph Dixon Crucible Co., which has closely followed the subject of graphite lubrication since its earlist conception, advises that best results are obtained by using flake graphite regularly in small quantities rather than by occasional applications. One should not wait until a bearing becomes hot and then throw in graphite until normal conditions are restored; if graphite were used at all times, hot boxes would be unknown and much time and valuable machinery saved.

There are upon the market a number of excellent devices for continuously feeding graphite or graphite

and oil to journals or cylinders, by the use of which perfect lubrication is assured If for any reason the lubricating system should fail, the parts will run for a long time without seizing and scoring, because of the graphite present on the metal surface. In addition, graphite permits the use of considerably less oil or of a cheaper oil, either of which is an economy.

The Joseph Dixon Crucible Co. prepares standard flake graphite in a number of degrees of pulverization, so that some grade is adaptable to any requirement. It also offers a large number of special graphite greases.

LUBRICATION BY MEANS OF GRAPHITE AND OIL

GRAPHITE, properly prepared and in suitable quantities, when used with lubricating oils, will furnish excellent lubrication, but like every other thing which men use, it needs intelligence and care to obtain good results.

The Graphoil Lubricator Co., of New York, has a system for feeding graphite with oil for purposes of lubrication, which has been in successful operation for several years, and under such a variety of conditions, that they have become fully convinced that a regular and constant supply of graphite in suitable quantities may be fed with the lubricating oil, with highly satisfactory results. To secure best results the graphite should be fine, and fed regularly in small quantities by the lubricating oil.

The graphite is mixed with a little oil to the consistence of a stiff paste, and put into the graphite cup. If this cup is designed for use with the cylinder of a steam engine the lower shank of the cup is connected with the steam pipe or into the valve chest.

The inlet for the oil which is at the upper or top part of the cup, is connected by proper fittings with the oil pipe of the oiling system which may be in use, whether hydrostatic or force feed, and the flow of oil when in operation is caused to fall upon the graphite in the cup, then to pass across the surface of the mass till it reaches an exit provided for it in the form of a suitable brass tube, cut away on one side and covered with wire cloth. This tube entends through the mass of graphite from the top to the bottom of the cup, so that whether there be much or little of depth to the mass of graphite there is always the slot in the tube, covered with wire cloth present at the surface of this mass through which the oil with the graphite may pass on its way to the parts to be lubricated.

In some cases where the flow of the oil is very slow owing to the small quantity needed, it has been found advisable to change the form of the receptacle in which the graphite is placed and a small cage is formed of wire cloth. In this cage, the graphite is placed and it is suspended in the graphite cup, where the oil may fall upon it and thus gather its portion of the graphite as it passes.

It is clear that by this process, an amount of graphite that would be sufficient to fill or obstruct a passage will never be carried forward by the oil, unless there has been a wrong installation of the cup, or gross neglect on the part of the attendant. The oil will not deposit the graphite unless it ceases to flow, or the flow comes so near a cessation that it is imperceptible.

The principle involved admits of a wide range in the style of cup, to suit the various purposes for which graphite may be employed with great advantage as a lubricant. These lubricators have no moving parts to wear or get out of order, and need no connections with the moving parts of the engine or machine, except in the case of a dry graphite feeder for air compressors.

WHY GRAPHITE LUBRICATES AND HOW

LUBRICATION is the minimization of friction and friction—the result of contact between 2 moving surfaces, is induced by the presence of those irregularities or inequalities of miscroscopical minuteness which occur even in such carefully finished bearings as appear perfectly smooth to the naked eye.

The logical way, then, to combat friction is to employ some agent to fill in and even up as far as possible these minute inequalities and experience has shown that graphite in the form of a soft gritless powder is effective for this purpose, that it is not affected by high temperatures and is remarkably adhesive.

A most important point to consider is the degree of fineness to which the graphite is reduced, the finer the better, for if it is to fill in and even up these always present microscopic inequalities then it must of necessity be of a microscopical degree of fineness in order to become deposited therein and satisfactorily perform this evening up process for it is obviously a physical impossibility for particles or flakes of graphite which are visible to the naked eye to deposit themselves in these minute depressions which can be detected only with the aid of a powerful microscope and which, as stated above, are always present to some extent in even the most carefully finished bearings.

While in many instances graphite alone will satisfactorily answer all purposes of lubrication it is, generally speaking, more desirable to use it in connection with either oil or grease, more frequently perhaps with the former than with the latter and here is still another reason for using only a graphite powder of impalpable fineness, that is a graphite which will float or remain in suspension for the longest period, otherwise precipitation quickly results, the graphite is fed more rapidly than is necessary or desirable, oil ducts become clogged, etc. Used in this manner not to exceed one teaspoonful should be mixed with each pint of oil; with greases use about one ounce (or say 2 teaspoonfuls) to the pound. Always mix thoroughly.

It is this finely powdered amorphous graphite that is used exclusively in the graphite lubricants made by the United States Graphite Co., which mines it in Mexico and reduces it by special process of pulverization and air-floatation to a soft and impalpably fine powder entirely free from grit.

It is then put up in packages as No. 205 Lubricating Graphite. It is also combined with nonfluid oils and greases in the production of Mexican Graphite Cup Grease of which there are 4 consistencies, the lightest of which is suitable for the lubrication of very rapid running machinery or machinery so constructed that the parts to be lubricated may be reached by means of a tube or common squirt cans. It is very desirable too for transmissions and sliding gears when they are enclosed in a case. The intermediate consistencies are intended for general use on crank pins, pillow blocks, main journals, etc., where a spring or compression cup is used, or on common bearings where the aperture is small. The harder consistency is for heavy open bearings and places where a high melting point is essential.

THE GRAPHITE AGE

WHY GRAPHITE LUBRICATES AND WHAT IT CAN SAVE

By Orrin E. Dunlap

WHILE the subject of lubrication is one that is constantly before humanity, it is doubtful if the problems which present themselves are considered in their full seriousness in order to effect possible economies and to obtain the highly beneficial results which may be secured through the reduction of friction and prevention of wear.

Cost of Lubrication

THE great majority of workers in the field of industry were born in the years which have elapsed since Col. Drake drilled the first petroleum oil well near Titusville, Pa., in 1859; hence it is little wonder that their principal education has been in the usefulness of oil and petroleum products as lubricants. The extent to which lubricating oil has entered into use throughout the world is well defined by the estimate which places the world's production of lubricating oil for the year 1908 at approximately 1,221,700,200 gal. This production may be accepted as the approximate consumption of oil for lubrication, and if you figure the cost at an average price of 25c per gal., you find the value of this oil to be $305,425,050. This tremendous and startling figure represents the astonishing toll collected from the industrial world by the energy devourer, friction. Friction is found everywhere; every revolving wheel, every surface rubbing on another, is affected by it, and it was for the reduction of this that in 1908, we paid, as estimated, the startling sum of $305,425,050, and this cost, as stated, is figured at the very low average cost of 25c per gallon for lubricating oil.

But these figures, despite their impressive nature, have to do with only a single year of industrial activity; and it has been estimated that this expense of lubrication, which is humanity's warfare against friction, triples every 15 years. As this additional cost is piled up, it adds to the cost of operation of every factory, of running every wheel, and the expense which must be charged up against the products. This rapid increase in the cost of lubrication is far from satisfying, particularly those engaged in the great movement for the conservation of our natural resources state that the world has in sight a supply of oil barely sufficient to last another half century. Thus, while in the mills, the factories, on the railroads, on the steamships, the world's supply of oil is being rapidly used, we realize that we are draining the reservoir which has no inflow.

It is the new things of the times that astonish us. As we come to know them better, that is learn more about them, our astonishment wears away, and we realize these new things of today are numbered among the old things of the morrow, standing as monuments to the world's progress—evidence that man's effort is meeting the demands of the time. So, when we see man making marvelous advancement in building and perfecting engines and machinery, we admit one age should be more advanced than the preceding age, but we also realize that these great modern engines and machine installations require more perfect lubrication than the crude engines and machinery of the past, considering the service and results they are expected to give.

Artificial Graphite

GRAPHITE has been known to man ever since the latter part of the 14th century as a mineral found in the earth, but the Graphite Age to which we particularly refer was born when the great electric furnaces of Niagara began making pure graphite; for this event came as an intimation to friction that it must cease its terrible annual toll upon the industrial world. Mankind has ever before it the picture of Father Time and his scythe. We know the toll he exacts, but standing over industry Friction always presents a more startling figure in demonstration of the toll it exacts, because with Father Time's call we have the promise of the hereafter, whereas when Friction does its work, it is wholly of a destructive nature.

Machinery of all classes, when it is not running well, has what we might term its sick days, its vitality, its energy being destroyed by friction. Mankind, too, has sick days, and then we hurry to the physician and drug store for the welcome remedies. It is not belittling the value of drugs or their purity to say that seldom do we buy drugs, even though they be marked "C. P." that are so pure as the graphite made for the purposes of lubrication in the electric furnaces, for it is possible to obtain electric furnace graphite that has a known purity of 99.90 per cent, and seldom do we find chemicals of this purity, even though they be rated, as we have stated, as being chemically pure.

We must recognize the fact that when Nature made graphite she had no choice of raw materials, whereas in the scientific method by which man makes pure graphite he has full control of both raw materials and the process. The needs of more perfect lubrication grow more impressive every day, and as we review what has been done up to this time in the field of synthetic electrochemistry, we recognize the wisdom of the Supreme Architect in thus early directing man's inventive genius to make a product well calculated to overcome thoroughly and effectively the troubles caused by Friction, for the making of graphite by man is one of the earliest developments in a field, the scope of which is destined to be widely broadened as man learns how to make other articles in great demand.

It is now possible to get practically pure graphite which has passed through a screen having 40,000 meshes, or 200 wires, to the square inch. When we realize that the finest bread and pastry flour passes through screens having 150 to 160 threads to the square inch, comparison between the flour we use in our homes and the graphite available tells us how much finer is this graphite than the flour we use. It will be admitted such graphite is beautifully fine, but scientific research and discovery enables us to enjoy as a lubricant deflocculated graphite, which is graphite reduced to the molecular condition.

While many have learned of the great value of deflocculated graphite as a lubricant, in the 2 forms in which it is obtainable, it is still in the infancy of its promotion, but day by day this remarkable product is taking a more firm hold on the industrial world, and appears destined to effect the most remarkable saving and economy every known in the field of lubrication since the world was created.

This graphite is not obtainable in powder form, only in the finished lubricants, diffused in oil and water. The saving it is effecting may well be portrayed by citing the case of 2 power stations in New York City, where the monthly consumption of cylinder oil has been reduced 66⅔ per cent, or from 5700 gal. a month to 1900 gal. If we apply this percentage of saving to the cost of lubricating oil as given above, we find that an annual saving of over $200,000,000 might be effected through the use of this new lubricant, and considering the possibilities it is believed very fair to say this is a low estimate.

Thus, while the cost of lubrication to the world may, up to this time, have been tripled every 15 years, the opening of the Graphite Age and the new possibilities presented in the field of industry, through perfect lubrication, are destined to effect a wonderful economy. We must conclude from this review of actual accomplishment that it is simply up to the users of lubricants to determine each for himself to what extent he will share in this great possible saving. If true economy be the watchword in the industrial world, each mill, factory, railroad, etc., will share in the grand result.

A film of oil, a film of plain grease, is known to split and break under pressure, but as we realize the full importance of graphite lubrication, we determine its merits to be based on the fact that a film of graphite will not break under pressure. Its benefits are that it fills in the irregularities of the metal surfaces, burying the points which engage and cause friction, and in doing this the graphite not only affords perfect lubrication but prevents wear.

Thus we find that graphite is a solid lubricant which will effect very pronounced economy in the quantity of lubricant necessary to obtain perfect lubrication; that graphite, unlike plain grease or oil, will not thin or melt and run away, and cause a wasteful use. How many times have you gone through a shop where oil or grease is used as lubricant and noted the soil on the floors and about the machinery which indicates loss of the lubricants in use. Blame the oiler, if you will, but he will tell you that he believed it necessary with the lubricant used to be thus wasteful if the bearing must be kept cool.

No oiler need be so wasteful with any medium that carries graphite as the lubricant, for as the carrier distributes the graphite to the metal parts which need lubrication, the graphite attaches itself to the metal surfaces imparting a film or veneer that is lasting. Irregularities of the surface are smoothed up, and when this graphite film is once thoroughly established the consumption of lubricant will be materially lessened. This result effects economy in the quantity of lubricant used, while the graphite film established prevents wear of the parts and materially reduces the cost of maintenance.

This has been termed by some as a "Machine Age," and no doubt we are all amazed by the clever work, the almost human work of some of the installations of today, but this only makes more clear that, as machinery is being perfected, lubrication must be more perfect. Is it unreasonable to point out that the modern installations of machinery are replacing installations now considered quite out of date because they do not respond to the needs of the times? We have no regret in this sending of the old machines to the junk pile. Let us be equally broad in considering lubrication; and let us not deny to modern machine installations the modern lubricants made possible by the Graphite Age.

ECONOMIC LUBRICATION

By W. A. Converse*

It should be the desire of each and every owner or operator of power or manufacturing plants, or any in which machines are used, to obtain the best and most economic lubrication of all kinds and types of machines being operated; therefore, the matter of selection of the most suitable and efficient lubricant for use on the machines used for different purposes, of different types and characters, and operated under different conditions, should receive more than passing consideration; in fact, should receive at least equally as serious consideration as does the installation of the machine itself. Many times, laboring under the impression that "oil is oil" results in serious damage, due to the lack of proper lubrication, and at all times in justifiable loss of power, due to friction or increased cost of lubrication.

Upwards of 20 yr. ago the Dearborn Drug and Chemical Works, appreciating the necessity of a more extended and thorough knowledge of the physical and chemical properties possible to obtain in a laboratory way on oils being used in practice, and from which were obtained the best and most economic lubrication, established the only completely and thoroughly equipped laboratory for the inspection and testing of lubricating products, at that time in existence, and is still maintaining this laboratory, having from time to time installed therein all of the most modern and best apparatus for the purpose.

After following out an investigation covering a rather extended period, they were in a position to compare conclusions arrived at, based upon laboratory tests, with actual results obtained in practice; and it was soon found that it was possible, after a careful consideration of the conditions under which a lubricant was to be used, to draft specifications for a product which would give the best and most economic results, these specifications being constructed in such a manner as to make it possible, by laboratory inspection, to ascertain whether or not a certain oil or other lubricant was suitable for use in a certain condition, and whether or not it would give the best lubrication possible to obtain. Therefore, in their estimation it became essential, in order to furnish products which would give the desired results, that the stocks used in the blending, compounding or manufacture of lubricants should be purchased absolutely on specifications covering not only their physical properties, but their chemical composition and purity.

It was also learned that oils for many uses of necessity had to be mixed, or blended, or compounded, as in the case of oils for use for the lubrication of steam cylinders. It is essential that the mineral stocks be compounded with proper percentages of the most suitable and efficient animal oil, in order to enable the consumer to obtain the most economic lubrication, irrespective of the amount of moisture contained in the steam.

It is a well-known fact that the mineral stocks are better lubricants than are the animal fats, if possible to use with them absolutely dry steam, but as it is impossible in practice to have steam delivered from the boiler to the cylinder absolutely free from any entrained moisture, and owing to the fact that the adhesion of a pure mineral stock is reduced by the presence of water carried to the cylinder by the steam, and the mineral oil removed from the surface much

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more readily, and the lubrication therefore impaired, the presence of a sufficient amount of suitable animal oil increases the adhesion of the mineral oil, and, as it is more readily mixable with water, retains the cylinder oil upon the entire surface of the cylinder, thereby insuring proper lubrication.

Since the animal oils available for this use vary greatly in their suitability for such purposes, owing to their possible decomposition when submitted to the conditions existing in the cylinder (some being readily decomposed, liberating fatty acids), it is essential that a thorough knowledge of this class of substances be had, and extreme care used in the selection of such material for use in the compounding of cylinder oils. It was found as a result of extended and careful investigation, that the most suitable of these for the purpose under consideration was the best, pure acidless, tallow oil.

It is not only essential, when selecting an oil for use on any type of machine or under certain conditions, that the physical properties of the mineral constituents be determined or noted, but that in case of steam cylinder lubrication the quantity of animal fat mixed therewith in compounding should be governed by operating conditions, and the least possible quantity of it used; sufficient, however, at all times to insure the desired result. The condition influencing the amount of animal fat to be added and used in compounding a steam cylinder oil is, first, that of entrained moisture contained in the steam. The percentage of animal fat contained should increase as the percentage of moisture in the steam increases.

Following along these lines, the Dearborn Company has for many years been marketing lubricants for many purposes, handling nothing, however, except those composed of the very best material possible to obtain, thus all products being strictly high-class in every respect. All stocks purchased are purchased upon rigid specifications. All shipments received from refineries, or elsewhere, are sampled and inspected in their laboratories before shipment is made. They are then again sampled following their arrival at the factory of the company, and another inspection made.

The same methods are applied to their products as they are marketed, each and every lot of compounded, mixed or blended oil being sampled and thoroughly inspected at their laboratories. This company has, during its existence in the oil field or market, been making more particularly a specialty of thoroughly high-class steam cylinder, dynamo engine, and marine engine oils. In selecting an oil for any purpose, under any conditions, all conditions governing are first thoroughly gone into and understood, and specifications constructed, and an oil made to comply with such specifications.

The line consists of pure mineral, cylinder oils, both filtered and unfiltered, for use under conditions demanding them, as well as both dark and filtered compounded cylinder oils, the mineral portion being selected according to specifications for the case at hand, and compounded with pure acidless tallow oil, in accordance with the demands of the case. All engine and dynamo oils were selected in like manner. Those marketed by this company are products of strictly high-class, Pennsylvania crude petroleums, steam-distilled and refined without the use of any acid or alkali.

Included, also, is a line of high-grade greases especially adapted for use for all purposes for which a grease is intended, as well as for special purposes.

PETROLEUM LUBRICATING OILS

LUBRICATING oils made by the A. W. Harris Oil Co. are refined from pure petroleum oil to suit the particular needs of every class of machinery. In compound engine lubrication, for instance, an oil that gives perfect results in the high-pressure cylinder may not prove economical or efficient on the low-pressure side, the lower pressure, the lower temperature, greater surface over which the oil is distributed, the greater weight of parts for which it is to form an anti-friction surface on the low-pressure side, create conditions which must be met by suitable variation of character and consistency of the lubricants employed. For this reason the Harris Oil Co. makes different grades of oils to suit the exact service.

The standard grade valve oil is used to lubricate the internal parts of steam engines under the most exacting conditions of pressure and temperature. Other brands which are cheaper, intended for rougher service, are also compounded for use in steam engine cylinders. A dark valve oil of a deep green color is compounded to suit the desires of the engineer who prefers this class of oil.

With superheated steam, the oil employed must be so constituted that its lubricating value will not be impaired under the unusually high temperatures and prevailing absence of moisture, which in the case of ordinary high-pressure steam is an important auxiliary to lubrication. Engines run under these conditions are supplied with a special brand of oil compounded for this particular service.

Other services for which oil is compounded especially are for ice machine cylinders, steam turbines, air compressors, gas engines, spindle oils, stainless oils, etc.

NON-FLUID OILS

ALL the mechanical genius which has been concentrated on improving machinery for the last 25 years has failed to provide bearings and other wearing surfaces, which leave the matter of lubrication a neglible quantity. The expert who glows with pride over his production of higher efficiency, whether in generating electric current or in mechanically seeding raisins, generally leaves his machine with a blemish in the matter of lubrication. It may be only in so far that he does not enlighten the users of his machine as to the proper lubricants to use or it may be because he is content to use bearings of types which are not susceptible of highly efficient lubrication. This leaves the solution of lubrication problems now, as ever, in the hands of the man who uses the machinery.

Unfortunately there is too little thought given to the problems of lubrication by the man who uses machinery. From the units in the power plant to the desk fan at his elbow, lubrication controls the situation in the matter of economical operation. The extent of frictional loss depends upon the selection of lubricants, of course, but not on the measure of friction alone does the highest economy of lubrication depend. A complete formula for economic lubrication includes the following:

1. Lowest coefficient of friction, embodying minimum consumption of power, least expense for repairs and least loss of production during repairs.

2. Lowest consumption of lubricants in attaining the above. and least expense for attention to lubrication.

3. Least damage to belting, goods, etc., and least fire risk from lubricants.

4. Least expense for lubricants. This item deserves consideration only after obtaining the first 3 specifications.

The Non-Fluid oil film is more adhesive than cohesive. It establishes an oil film on the surfaces it aims to lubricate. It coats the surface by contact, through adhesion. Contact with the moving shaft in a bearing (obtained by compression in the heavier grades or gravity in the lighter) is sufficient to force a separation and prevent metal to metal contact. A clean shaft will draw in a complete film in 10 or 12 revolutions and the friction rise of temperature is overcome because lubrication begins at once. The melting point of Non-Fluid oil is high, the purpose of this is to prevent melting under atmospheric or local temperatures which might otherwise destroy the natural consistency of the lubricant. Non-Fluid oil is not subject to the congealing influence of cold weather, obviously then, one grade suitable for the work, lubricates unifromly the year around.

The neutrality of Non-Fluid oil, due to its freedom from matter which is subject to oxidation and the formation of fatty acids makes it adaptable to bearings of the ball or roller type which are finding popularity in shafting and certain special machinery, in any bearing this quality is important.

The non-dripping quality of Non-Fluid oil is most apparent perhaps in the lighter grades which to all appearances possess qualities of fluid oil. These grades resist flowing until brought into contact with a shaft or impelled by the vacuum of the bearing. The flow ceases at the end of the bearing where the pressure disappears. In ring or chain oiling types, the light grades of Non-Fluid oil prove highly efficient. However low the supply may be in the reservoir as long as the chain or ring is immersed an ample quantity clings to it and is conveyed to the shaft. In no sense is the feed dependent upon the depth of the supply.

For general use Non-Fluid oil is prepared in 2 densities. One is suitable for use in place of oil without changing the method of applying. The other corresponds in density to ordinary cup grease and is applied in like manner. In addition to these a great variety of grades are offered where lighter or heavier densities are required.

Non-Fluid oil was originated by the New York & New Jersey Lubricant Co., of New York, and has shown high efficiency and economy in every class of service.

VACUUM OILS

IT is well recognized that oils differ, that is, one gives better lubrication than another. It is also evident that one part of a machine runs more easily with one class of oil while another part runs easier with a different class. It follows, therefore, that there is a possible oil for every friction place that will give better results at that place than any other oil will. This draws the line to a fine point but it illustrates a practical fact of greatest importance in the field of lubrication.

The maker of oils should consider all parts of machinery, group them as friction producers, in 20 or 30 groups perhaps, and produce oil to give more ease to its group than any other possible oil. This is the aim of the Vacuum Oil Company of Rochester.

The difference in value between 2 oils and between 2 sets of oils is the cost of what one saves and makes and the other doesn't. Some of the items of expense due to excessive friction can be measured more or less accurately but some can not be measured at all. They all count, however, for profit or loss.

The Vacuum Oil Co. has for a long time manufactured a cylinder oil of the highest grade, the same can be said of its high-speed engine and dynamo oils. It also manufactures a high grade general engine oil and spindle oils, other oils for special purposes are compounded to suit conditions of use.

PETROLEUM PRODUCTS

CYLINDER stocks, which form the base of all steam cylinder oils made by the Waverly Oil Works Co., are the residue from Pennsylvania crude oil which is left in the stills after all other products have been distilled.

While some straight cylinder stocks are used as cylinder oils, the most satisfactory oils are a compound of cylinder stock and high grade animal oil. Only the highest grade animal oil is used to insure freedom from fatty acids. The animal compound causes the oil to adhere to the moist cylinder more tenaciously, therefore, while such oils are higher priced they are more economical. Where condensed steam is used in ice-making or for distilled water a pure mineral oil is required.

In cylinders operated with super-heated steam, which is absolutely dry, a pure petroleum oil should be used which has a fire test not less than 680 deg.

During the past 10 or 20 years the character of engine and machinery oils has changed completely owing to the revolution that has taken place in the construction of steam engines and all classes of machinery. In former years, these engines and machines were all more or less ponderous, slow moving and were not generally equipped with oil cups. The slides, journal, crank pins and the bearings were always more or less of an open character and consequently a heavy thick oil was desirable which would not run off the bearings.

In the present day, however, on high speed engines and machines having close fitting bearings, equipped with automatic oil cups, a thin oil of quite high fire test and exceptionally real viscosity must be used.

For oiling such machines, the Waverley Oil Works Co., manufactures a number of oils for special machines, that is, for such use as high speed engines, splash engines, turbines and heavy machinery shaftings.

Oils for use in gas engine cylinders differ decidedly from those suitable for lubricating steam cylinders. Practically all the oil that enters a gas engine cylinder is destroyed by combustion and therefore the first quality a gas engine oil must have is freedom from carbon so that when it burns it leaves no deposit. It requires no expert to determine the amount of carbon oil contains as the carbon is what causes the dark color and it must be removed by filtering. A green or red oil should not be used for gas engine lubrication and nothing darker than a pale or golden colored oil is sufficiently free from carbon.

Suitable oil for gas engine lubrication must also have a very high fire test to enable it to perform its work before it is destroyed by combustion. Its viscosity must be high so that it may retain its lubricating power at high temperature.

Oil engines require oils identical in every respect with gas engine oils. Those manufactured by the Waverley Oil Works Co. are entirely suitable for oil

engines. These oils have a fire test of 480 deg. and the above necessary qualities for gas engine lubrication.

Dynamo oils made and recommended for use by this company have a pale color and a fire test over 470 deg., the viscosity being something more than 220.

The conditions prevailing in air compressor cylinders is quite similar to that in the gas engine with the exception that temperature of the air compressor never reaches such a high point as it does in gas engine cylinders. On this account a darker and at the same time a cheaper oil may be used for the vast majority of machines. An oil to be satisfactory and at the same time economical for lubrication of air compressor cylinders should have a fire test of 470 to 480 deg. and a viscosity test of 220 or over. These qualities are met by the air compressor oils which are manufactured by this company.

SCIENTIFIC LUBRICATION

WHAT IT IS

By George Baum

NATURE is the Master of Scientific Lubrication! The nearer man can approximate Nature, the greater his "science." The Universe and all its manifold creation runs smoothly and without friction because of this marvel of perfect, scientific lubrication. From the knee joint of the mastodon to the socket of the humming bird's wing, there is shown this wonder in Nature's marvelous economy. The ether surrounding the earth is a lubricant of wonderful efficiency, giving absolute protection from friction.

Why It Is

THIS last word just used is the "why" of lubrication always—for friction means useless destruction of power. It is power gone to waste, without adequate return.

The God-made machine has every part protected from wasteful friction by scientific lubrication. For instance, take the knee with its oil and the cap which protects and seals that oil. After strenuous exertion, or some burning fever, this oil runs partially dry and the knee becomes stiff and the joint creaks. A rest (or relief from the fever) allows a fresh supply of oil to accumulate and the human machine again runs smoothly on till old age dries up the fount entirely.

Given, then, the fundamental fact that lubrication is solely to conserve energy (power) by reducing friction to a minimum, then we come to a discussion of the best methods for man to adopt in his man-made machines—his mechanical joints and bearings.

How Best to Lubricate

THE fundamental object is to interpose some material between the 2 friction creating surfaces so that there may be perfect contact between those surfaces. It means something of a very oily nature capable of withstanding enormous pressures, without internal friction of its own molecules, yet readily adapted to filling with a microscopical film, all the imperfections of the mechanic in producing his contact surfaces. All this must be with the expenditure of no energy.

Public opinion differs on the method. One condition requires one system of lubrication, while another problem brings forth an entirely different phase. All rely upon something of an oily or greasy nature, and the results depend much upon the interest devoted to a systematic study of the correct methods of application.

Animal, vegetable and mineral oils have each their admirers.

Animal oils—lard oil—yield wonderful oilness of great endurance and for sources of friction in the absence of live steam are found to meet nearly the requirements of a perfect interposing medium for the prevention of wear. The great expense renders them practically unavailable to the public, but where expense is no factor they find practical application.

Mineral oils have their best application where high temperature, steam or water infection is involved. As they are little effected by such agents and as they yield a well known oiliness they find extensive use in this line.

The chief drawback of such substances is in the method of application, and for simple sources of friction this has been a serious problem. The fluidity causes imperfect contact. The fluid oil fails to remain at its post of duty and inefficiency and great waste results. Many prefer to favor the waste in order to take advantage of the oiliness rendered. Each individual must choose for himself, but he should do so only after exhaustive tests by himself or by a well known authority.

In order to cope with the fluid oil application, greases of a self retaining body have found application to advantage. There are 2 general classes of these: One following the animal oil lines, the other mineral oil. The resultants are known as tallow greases and mineral greases.

These consist of some emulsifying agent to hold the fluid particles together.

With the tallow type of grease the initial animal product has a good body at low temperatures. Here only a trifle of soap aids in maintaining its consistency at high temperatures. A boiled tallow with a very small proportion of soap has universal use where live steam or water does not interfere. Thus is created an animal oil of self retaining body with all its excellent features. Albany Grease has been the representative of this type for 43 years. Improvements in method of manufacture and degrees of hardness or softness have been made for varying temperatures but Albany Grease stands today in the fore front of lubricants for use on machinery of all kinds.

The mineral greases utilize the effectiveness of mineral oil and likewise look to the emulsifying power of soap as their body retainer. Since the mineral oil is very fluid they require larger percentages of soap to produce any sort of body. There are many such products available and their efficiency depends on the proportion of dissolved soap and the quality of the mineral oil.

The oils are applied by means of an oiler and constant attention is demanded. The greases may be applied through more or less automatic cups and thus prevent waste and uncleanliness.

ALBANY GREASE

SELECTED tallow is so blended in Albany grease as to have the lowest melting point consistent with ability to stay in the cup at the temperature in the surrounding air. It is usually applied by means of grease cups but may be applied in any manner the engineer desires which is suitable for the work. These greases are made in 7 consistencies: No. 0 is a soft grease used in extreme cold weather and exposed bearings, adaptable for cable ways, gears, slides, chains, elevator ways, etc. No. 1 grease is of medium consistency used in cold weather on ordinary journals

and slow running journals with heavy pressure, and in warm weather may be used in transmissions of automobiles, motor boats, etc. No. 2, commonly known as winter grease in engine rooms, is used in moderate and warm weather on general shafting, loose pulleys, main bearings, etc. No. 3, the summer grease, is universally adapted to stationary, marine and tug boat engines. No. X, XX and XXX are the heavier greases used for bearings that are heavily loaded or that run unusually warm. The melting points are higher than in the greases formerly mentioned and are especially adapted for unusual conditions of high temperatures.

THE REQUIREMENTS OF A BALL BEARING GREASE

By Herbert L. Towle

REQUIREMENTS of a ball bearing grease are primarily two: first, protection of the working surfaces; second, lubrication. In the best ball bearings, the races and the balls themselves are brought to a mirror-like polish after the final grinding, and this polish, which leaves no scratches to be detected under a strong pocket magnifier, is an important element in the durability of the bearing. Rust obviously destroys the surface by converting it into a series of craters and ridges, thus causing the load to be concentrated in a few points, which are presently crushed and crumbled. Protection of the surface is therefore of the first importance; lubrication, though sometimes hastily assumed to be unnecessary, is in fact essential to durability, since the balls necessarily rub against their separator, and in addition have a microscopic creep at the fringes of the loaded contact points, where the compressed surfaces flatten and resume their normal curvature.

Any good mineral machine oil will lubricate a ball bearing and exclude water. It might therefore be supposed that a grease would do the same, but this may or may not be true. Greases are much more variable in composition than mineral oils, and many greases are seriously detrimental to ball bearings, though they may serve their purpose fairly well in the lubrication of plain bearings. The following characteristics are essential to a good ball bearing grease: (a) Neutral chemical composition, neither alkali or acid being present. (b) Freedom from solid substances in suspension, such as mica, coarse graphite, talcum, etc. These substances may have a usefulness in plain bearings, but in a ball bearing the balls must roll over the solid particles like a stone crusher, and usually there is little or no clearance between the balls and races to permit this, without injurious wedging. A ball bearing grease which is not to injure the bearings must be entirely free from suspended solids of less than molecular finess. (c) Freedom from resin and other gummy fillers. (d) The grease must be permanent, both chemically and physically.

The first requirement is sufficiently explained by what has already been said regarding the effect of rust. All greases made from animal fats turn rancid sooner or later, or are preserved by means of chemicals which themselves are injurious to ball bearings. No such grease should ever be used in a ball bearing. Free alkali is equally objectionable, and this may be found in certain artificial greases to which reference will presently be made. The last requirement, namely, chemical and physical stability, is explained when we consider that a ball bearing, unlike a plain bearing, is packed with grease to last for 6 months or a year. An animal fat would turn rancid in much less time; the grease which tends to gum or harden will likewise do so long before repacking should be needed. It is likewise desirable that the grease shall not work out thin, since in some cases efficient protection against dust or water depends on the grease maintaining its consistency.

When the above requirements are considered, it is clear that they exclude a large majority of the commercial plain bearing greases. A ball bearing grease is likely to be excellent for plain bearings, but the contrary by no means holds true. After investigating extensively, the Hess-Bright Mfg. Co. has adopted as best suited to the requirements of its ball bearings, a very pure and carefully compounded mineral oil grease. This term applies broadly to a considerable class of lubricants, which are artificially made from mineral oil by suspending it in a body made by saponifying an animal oil with a caustic. The caustic does not act on the mineral oil, but only on the animal oil, with which it forms a soap which holds the mineral oil in suspension. According to the proportions of oil and soap, and the original density of the oil itself, the resulting greases may be anything from almost fluid to a hard paste.

Sponge greases, like others, vary in quality according to the ingredients used, and the care with which they are treated. Pennsylvania oil stock makes better greases than Texas oil. The animal oil is generally horse oil, and it should be used very fresh, as it deteriorates shortly after being rendered. Of particular importance is the care used to exactly neutralize the horse oil. If there is an excess of horse oil, it will in time turn rancid. If the caustic soda or potash is in excess, the grease will be alkaline.

It may be remarked that an oil grease may give excellent results in plain bearings yet be to alkaline to be safe in ball bearings.

The Hess-Bright Mfg. Co. has fixed on 2 densities of sponge grease as being suitable for general requirements. The No. 1 or heavier grease is suitable for speeds up to about 300 r.p.m., and the lighter grade No. 2, for speeds up to 2000 r.p.m. Above the latter speed mineral oil alone must be used.

As with other things, a certain amount of judgment is required in the selection of grease. For example, it is found that oil grease emulsifies slightly when mixed with water. In the presence of water or steam, therefore, this grease should not be used. The choice then falls upon vaseline or petrolatum grease. These greases are the residue left in crude oil after the naphthas, kerosenes, and lubricating oils have been distilled off. Their viscosity is natural, not like that of artificial grease, the result of blending with other substances.

KENT GREASE

KENT Greases are so compounded that their consistency does not change with temperature, thus when the proper consistency of grease has been determined for the particular work, it can be used during hot or cold weather since it will not change its consistency between 20 deg. below 0 to 350 deg. above. In order to meet all requirements in lubrication, these greases are made in 4 grades of consistency: No. 1X is the softest and is intended for light running machinery and for feeding through long tubes

in automatic compression cups. No. 2X is that used on shafting with iron or tin shafting cups and on engine and machine bearings where the automatic compression cups are employed. It is the most satisfactory grade for hydraulic elevator service. No. 3X is of heavier consistency than 2X and is adaptable, therefore, to heavy bearings and fast running machines. The heaviest grade is 4X, made especially for open bearings, for locomotive bearings, flour mill rollers, rolling mill journals, etc.

KEYSTONE LUBRICANTS

IN well-designed and properly proportioned machinery, loss occurs only through friction, and it is of supreme importance to the engineer who designs and the operator who operates the machinery to determine the loss from friction in these constructions; hence, the reduction of the lost work by friction has become an important branch of applied science.

It has been estimated by high authorities that the power expended in mills and workshops has been

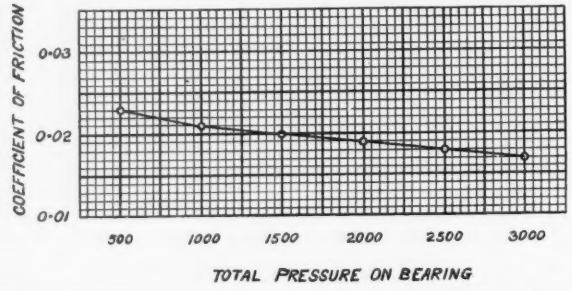


FIG. 1. COEFFICIENT OF FRICTION WITH KEYSTONE GREASE

consumed in overcoming the friction of insufficiently lubricated surfaces. Cornut and others have found a variation of friction from 15 to 20 per cent by simply changing the temperature, and have also found that a reduction of 50 per cent of the friction loss has been secured by change in the lubricant.

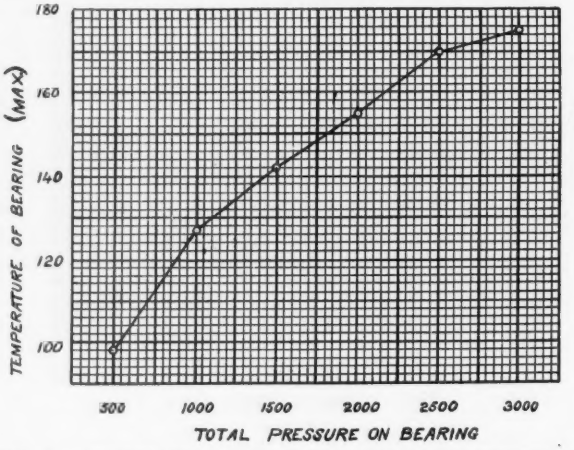


FIG. 2. TEMPERATURE RISE OF BEARING WITH KEYSTONE GREASE

In a cotton mill, Mr. Davis found a change to an extent of 10 to 15 hp. by changing the lubricant, hence, the power saved by proper lubrication makes it important for manufacturers and operators to choose carefully the lubricants to be used.

A good grease at a reasonable price is an ideal lubricant such a grease will be compounded of good materials, will give a low and constant coefficient of friction, and will remain in the bearing to do its work without change until it has all been used up.

The Keystone Lubricating Co., of Philadelphia, which took up the subject of grease lubrication over 26 years ago, at that time decided that the highest criterion of a high grade lubricant would be to do the work of a perfect grease. The company has developed its grease after patient research, and produces a pure natural product composed of high grade, refined, petroleum oils, which are not subject to decomposition, rancidity or deterioration under any working conditions regardless of speed or pressure and which maintain in the bearing a slippery, non-corrosive film, having a minimum co-efficient of friction. These greases are so compounded that they have no objectionable body or corrosive substances, to eat shaft or bearing, and do not leave gum or sediment behind.

Tests made on Keystone greases to show their lubricating value have given a low coefficient of friction and low temperature as shown by the curves presented herewith.

SCIENTIFIC STEAM CYLINDER LUBRICATION

DID you ever stop to think what becomes of the oil fed to a steam cylinder? The object of feeding such oil is of course to lessen the friction of valves, piston, and piston rod, but some lubrication specialists declare that a large part of it runs through and

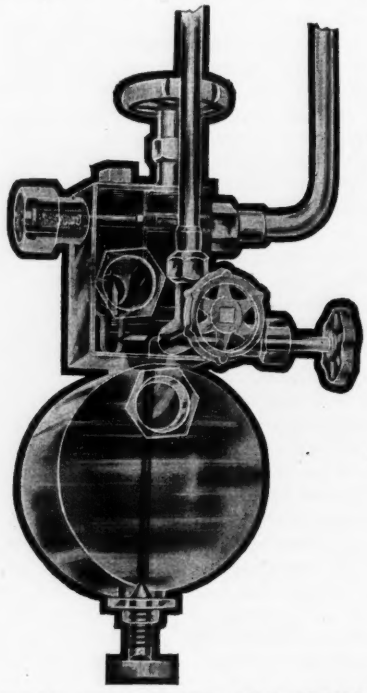


FIG. 1. INTERIOR VIEW OF THE OHIO GREASE CYLINDER LUBRICATOR

goes out of the exhaust without serving such a purpose. It does this partly because of the composition of the oil and partly because of the way it is fed.

Most cylinder oils are made of cylinder stocks with the addition of neutral oils and animal fats such as tallow or neatsfoot. This compounded oil, fed at an average temperature of about 70 deg. F., is allowed

to enter the steam line in solid drops, the assumption being that the steam while carrying it to the engine will atomize it. Ordinarily the distance from the lubricator to the inlet valves is seldom more than a few feet, and under these conditions it is likely that the drop is still a drop, or at best several smaller drops when it reaches the valve. Under these circumstances it would be likely to fall to the bottom of the cylinder and to be carried off with the exhaust steam without doing any work of lubrication.

Evidently a way to overcome these troubles is to use a lubricant that will stay where it is put, then to feed it in such a way that each particle has a chance to do its share of the work.

With this end in view, a system has been devised by the Ohio Grease Lubricant Co., of Loudonville, O.

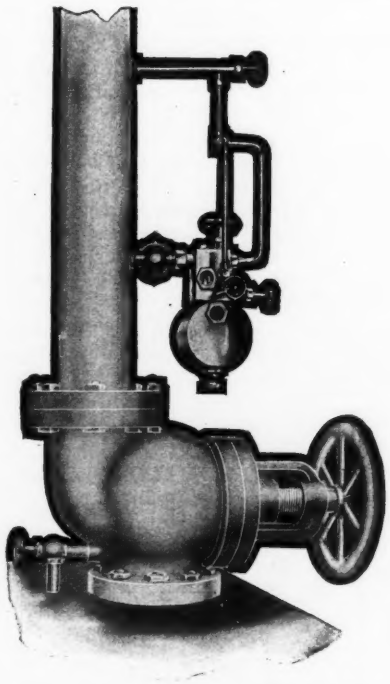


FIG. 2. OHIO LUBRICATOR ATTACHED TO STEAM PIPE

There are 2 distinct parts to the system, namely, the grease which is known as Ohio Cylinder Grease, and the Automatic Lubricators that feed it.

This grease is a pure concentrated petroleum lubricant made by a secret process from the best cylinder stock obtainable. It has high viscosity and fire test, contains no acid or animal matter, is well adapted to all steam pressures, and is condensed so that it has a high lubricating value. This grease is fed to the cylinder by a specially designed lubricator, which is furnished by the company, and of which illustrations are given.

In action, this lubricator automatically heats the grease to 190 deg. F., feeds it in drops and then superheats and atomizes each of these drops, thoroughly mixing them with the steam before it enters the cylinder. This enables the steam to deposit a thin uniform film on all surfaces with which it comes in contact so that all parts of valves and the cylinder receive an equal share.

The manufacturers state that this placing of the grease where it is needed results in lessening the amount required, extending the life of the packing, reducing the wear and tear on the machinery, and cutting down the power used up in friction.

PHILADELPHIA GREASE

IN the manufacture of Philadelphia Grease, the mineral oil undergoes processes of cooking, mixing and cooling during which the ingredients are compounded according to the density desired, which varies from a very soft mass to the grease of hard, firm consistency. The makers of this grease recognize that the lubricating value depends in a direct ratio upon the lubricating value of its component parts, and grease for a special purpose has its ingredients chosen according to the use for which it is intended. By the method of manufacturing, the grease is kept neutral, that is, contains neither alkali nor acid and is free from corrosive materials.

To meet all conditions under which greases may be used, Philadelphia grease is made in 8 different densities, all of one quality, which gives a range of application that covers all classes of machinery from the heaviest to the lightest bearings.

MICA FLAKE LUBRICANT

EXPERIENCE has shown that certain minerals presenting a flake formation when pulverized finely have proved very effective for lubrication when mixed with either oil or grease. Mica flake is preeminent in that respect, for the reason that no matter how finely you grind mica flake it is still a mica flake. Its peculiar formation cannot be destroyed. Even when ground to a fine impalpable powder, each individual particle is still a flake—a thin, flat piece of mica, presenting 2 smooth parallel surfaces.

The mica flakes enter the minute depressions that appear in the rubbing surfaces and fill them. If for example the surfaces of any bearings have become irregularly worn, due to the heavy load put upon them, or from other causes, mica flake fills in and overlays until a new surface of symmetrical outline results.

The journals and bearings are practically resurfaced, giving a degree of smoothness unattainable by the highest polish. Thus, by presenting uniformly true and smooth bearing surfaces, the mica flake gives the lubricating oil full play, and separates or keeps apart the bearing surfaces.

The continued heat in a hot bearing is due to continued friction. Heat in the shaft or axle will communicate itself to the journal and vice versa. There is little chance for the heat to radiate, and the continued friction simply adds to the difficulty. Eliminate the friction and you give the heat a chance to dissipate itself. Mica flake is a non-conductor, and besides separating the 2 metal surfaces, it thus prevents the interchange of heat between the bearings, giving each bearing a chance to cool separately.

By the use of mica flake lubricant the amount of pressure which may be carried on a journal without over-heating may be increased and it has also been found that the amount of oil necessary to obtain minimum friction is much less.

Mica flake will not cake or harden for it is cleanly, nothing but white mica with all impurities eliminated, so that it will not of itself damage or soil, and even mixed with oil it will not blacken or discolor.

NO MATTER HOW WELL I may do a thing today, there will be a better way of doing that thing tomorrow.—System.

SCIENTIFIC APPLICATION OF LUBRICANTS TO POWER PLANT MACHINERY

By J. Wm. Peterson*

IF the operating engineer of 25 years ago could suddenly drop into a modern power plant he would probably be more impressed with the improvements in lubrication than in any other feature of the plant. The engines and boilers now in use would look to him about the same as those with which he was familiar except for the increased size. The same is true of feed-water heaters, economizers and pumps, but to his mind engine lubrication meant a few oil holes in the engine which had to be visited every so often and treated to a dose of oil from his trusty oil can, or in some instances the bearings were provided with grease cups and instead of a dose of oil, he would, on his regular rounds, give these cups an extra twist. Nothing similar to this is now seen in the modern power plant.

Economical lubrication requires the installation of modern scientific apparatus which will automatically apply the oil in a manner that will do the most good, it being evident that in striving for oil economy the amount of oil used may be reduced to a point where friction becomes excessive. Furthermore, poor lubrication increases wear and tear, reduces the life of machinery and wastes a large amount of power by friction, which latter, of course, results in increased fuel consumption.

The proper lubrication of bearings as well as cylinders on all power plant apparatus is worthy of the most careful study, for the economy of an expensive engine or machine may be reduced below that of a cheap one simply because it is not properly lubricated. Real economy is possible only when, (1) every bearing is continuously supplied with a stream of oil so that the rubbing surfaces float past each other on a film of oil instead of coming into metallic contact, and (2) when the used oil is automatically collected, filtered, purified and used over and over again. The first reduces the cost of producing power and the second the cost of attendance and oil necessary to good lubrication.

Modern power plants are, as a rule, laid out so that the whole scheme is interchangeable, that is, any engine can be thrown on any boiler or group of boilers, or, any generator can be made to supply current to any feeder. The lubrication engineer, however, has 3 alternatives to work upon in the design of a system scientifically to lubricate a given plant. He may either install a central system in which the main supply of oil is stored at one place and conveyed to the bearings of the various power units by means of main feeding and branch pipes to each machine, or he may make each individual engine, pump, air compressor, etc., a unit by itself, that is each one supplied with its own oiling and filtering system, or he may provide a combination of the two, that is, he may provide one lubricating system to take care of a group of machines.

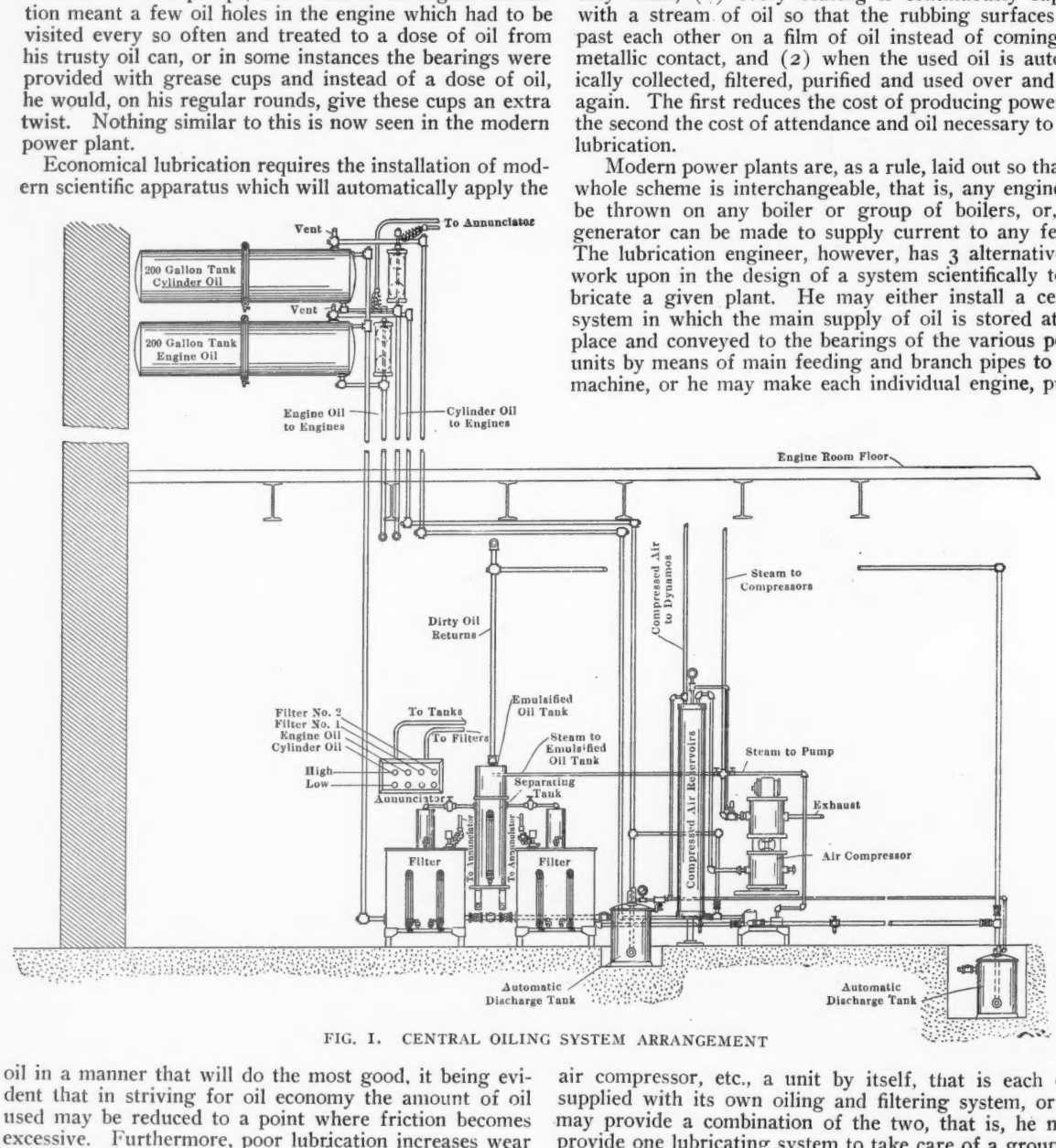


FIG. I. CENTRAL OILING SYSTEM ARRANGEMENT

In the application of the first system it is necessary to install a large part of the apparatus in duplicate in order

*Lubrication Engineer, The Richardson-Phenix Co.

to insure continuous operation of the plant. The amount of duplication depending a good deal upon the arrangement of the plant, the susceptibility of the various parts to injury, the value of continuous operation and also to the ideas of the designing engineer.

Figure 1 shows the general arrangement of the apparatus for a central oiling system in an industrial power plant in which the oil is automatically handled by compressed air.

The filtering apparatus is located in the basement of the power house and all used oil flows from the engines to the filters by gravity. After being filtered it flows into an air oil lift which automatically delivers the filtered oil up into an overhead reservoir. From this point, the oil flows by gravity to the various machines to be lubricated, after which it again returns to the filters for filtration, and so on continuously. This system also provides automatic cylinder lubrication from an overhead reservoir. Figure 2 is a plan of the engine room showing the method of connecting the oiling system to the various engines and other machines.

There is, of course, almost an infinite variety of arrangements of such a system. In many of the larger power plants the oiling system is extended to include many refinements, such as connecting the bearings on all smaller machines, ring oiling, motor and generator bearings, etc., to the oiling systems and maintaining a continuous circulation of clean, cool oil through every bearing.

Figures 3 and 4 show the second system as mentioned above, that is, the individual system in which all of the apparatus necessary for the lubrication of a given unit is located on or at the unit. This is a typical arrangement of this type of oiling system.

Briefly the operation of an individual oiling and filtering system may be summarized as follows:

A receiver or drain well is located below the floor so that the used oil from the various bearings will flow to it by gravity. A pump driven from the engine takes this used oil from the drain well and delivers it to the filter. The filter thoroughly removes all particles of foreign matter held in suspension and also separates entrained water which is picked up at the various places, notably in the cross head guides where steam leaks by the piston rod packing and condenses. If this water is not thoroughly removed the oil becomes thoroughly mixed with it and an emulsion is finally produced which will not circulate and has very low lubricating value. The clean oil taken from the filter then either flows by gravity or is forced by a pump through a system of piping which distributes it to the different points to be lubricated, at each of which a sight-feed oiler with adjustable valve is provided so that the oil can be regulated to a nicety to meet the requirements at each individual point.

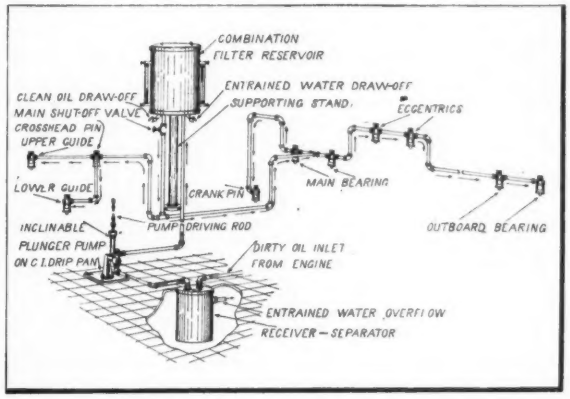


FIG. 4. DIAGRAMATICAL ILLUSTRATION OF OILING SYSTEM FOR SMALL PLANTS

The typical commercial system illustrated in Figs. 3 and 4 is for small units; for large units the system is similar in operation and only differs in a few details. It will be noted that the filter is mounted on the engine frame and that the oil flows from it by gravity to the various points of lubrication, while for large units the filter is usually set on the engine room floor and the pump takes the clean oil from the filter and forces it through the feed line into which is also attached a sight glass overflow stand to maintain a constant head.

This individual system, in which all of the apparatus necessary for any engine or machine is grouped about that unit is the type which should be used in the thousands of small size individual and isolated plants in office buildings, hotels, etc., and for this reason, I have thought it necessary to describe it in greater detail than the central system, which is more practicable for the larger central stations.

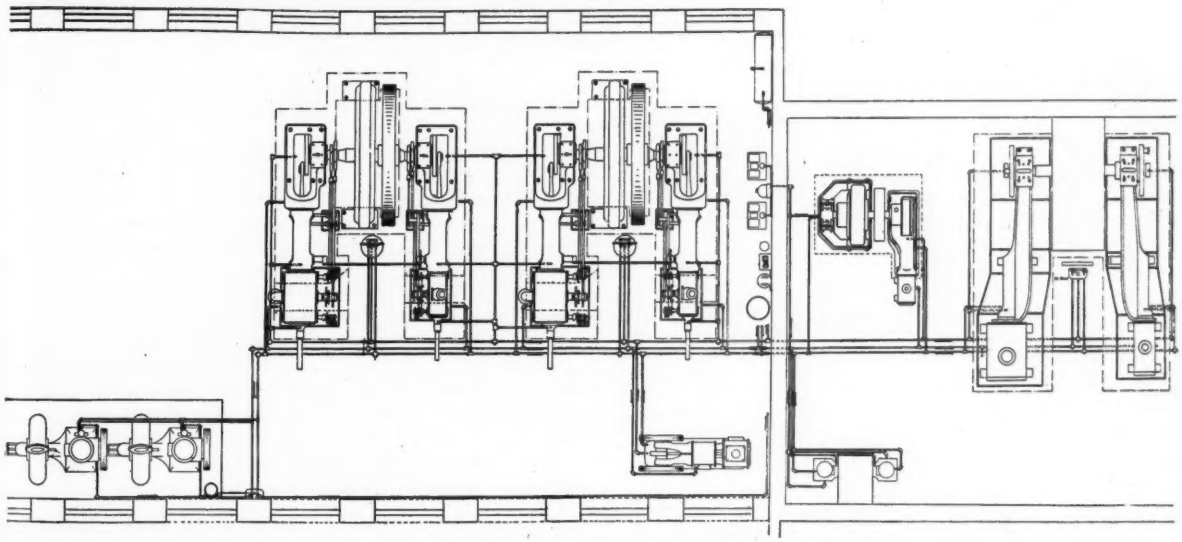


FIG. 2. CONNECTIONS OF OILING SYSTEM IN ENGINE ROOM

From the illustration shown it is evident that with the individual system, no overhead piping or duplication of apparatus is required, and furthermore, the whole system can be easily attached by any engineer or mechanic of ordinary ability. The ease of setting up the individual type system has been made doubly so, for at least one manufacturer now sells a complete system ready to attach to an engine, all that is necessary for him to know being the size of the engine and the number of points to be lubricated.

The third alternative as mentioned above is a combination of the central and individual systems. This combination may consist in having the piping and sight-feed oilers on each unit arranged as shown in Fig. 4. Instead, however, of having a filter, pump and receiver for one engine only, each pump, filter, etc., may be connected up to handle the oil from 2 or more units.

Another variation that is sometimes introduced is that even when all the engines are equipped with individual oiling systems an overhead storage reservoir is installed in which new oil from the barrels is stored and a pipe line is extended around the plant connecting into each individual oiling system. From this central supply tank additional oil necessary for up-keep can be drawn, and in case of accident may be used as an auxiliary to any system, thus eliminating the most remote possibilities of shutdowns.

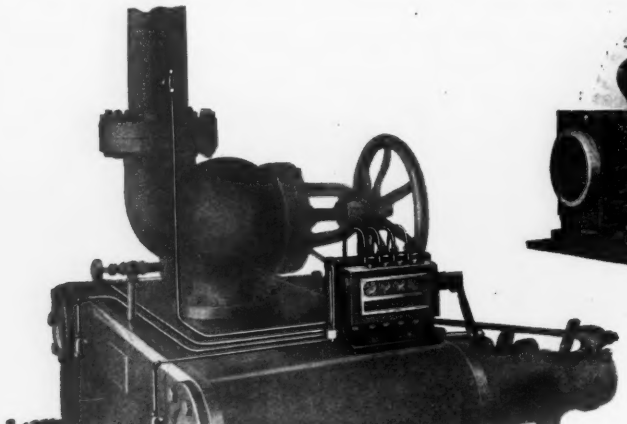


FIG. 5. CORLISS ENGINE CYLINDER OILED BY FORCE-FEED LUBRICATOR

Cylinder Lubrication

THUS far nothing has been said about cylinder lubrication. There are, however, also many recent improvements which tend to more economical utilization of cylinder oil. Of course, cylinder lubricating systems are not as elaborate as those for bearings because no provision has to be made for the recovery and purification of the oil. All oil that is fed into steam cylinders passes out with the exhaust and is lost beyond recovery. At least no satisfactory practical method of thoroughly removing oil from exhaust steam and using it over again has yet been devised; therefore scientific lubrication consists in reducing friction by using as little oil as possible, whereas bearing lubrication really consists in using as much oil as possible but preventing any of it from going to waste and of thoroughly purifying it so that it can be used over and over again.

For cylinder lubrication a mechanically driven force-feed lubricator, in which the oil is positively and at regular intervals forced by means of pumps into the cylinder, has been generally adopted. The regular practice is to install a separate lubricator for each engine, air compressor, pump, etc. For lubricating the cylinders of large engines, and other steam driven power plant apparatus it is not now considered enough to merely feed a drop of oil at stated intervals with the entering steam, the usual accepted good practice now being to provide 3 or 4 feeds for each cylinder, one feed connecting with the steam supply pipe, one for each of the steam inlet valves and one feed for the piston rod packing box. Feeding the cylinder oil into the cylinder at 3 points instead of one does not necessarily increase the oil consumption, as it has been clearly demonstrated that the same amount of oil divided up as above will result in better lubrication. Figure 5 shows the arrangement of a standard 4-feed lubricator applied to a Corliss engine feeding the oil as outlined above.

These cylinder lubricators are as a rule periodically filled by hand, although in many plants they also have been made entirely automatic by feeding the oil by gravity from the overhead storage reservoir to all the mechanical lubricators in the plant, each of which is provided with an automatic float valve located in the lubricator reservoir. This arrangement does away with all hand handling of cylinder oil.

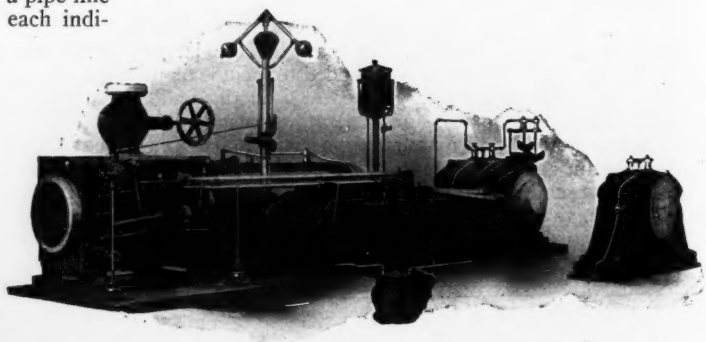


FIG. 3. OIL SYSTEM FOR SMALL PLANT

These remarks make it plain that the modern lubrication of power plant apparatus has progressed beyond the point of the oil can and some oil holes.

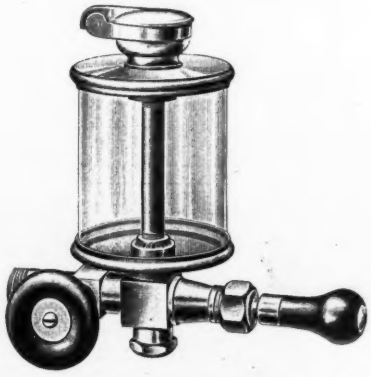
Up-to-date methods of reducing the amount of cylinder oil to a minimum by scientific application and of using bearing oil over and over again have resulted in an oil saving of 25 to 90 per cent, besides decreasing the cost of maintenance and increasing plant efficiency by reducing power consuming friction to a minimum. Frequently these modern lubricating systems increase engine efficiency from 2 per cent up and it has been figured out that even an increase of 2 per cent in efficiency, will pay for a system in one year, to say nothing of the reduced cost of oil and attendance. There is probably no place in a power plant where the engineer can secure better returns for the money invested than in improving lubrication.

"IT IS A COMMON fault not to give the proper attention to the dangers of hot bearings. Of course, we all get busy when an engine bearing heats up because if not properly taken care of it means a shut down. What I have in mind particularly is the line shaft bearings in isolated places. I know instances where fires have come from bearings sparking, particularly where the air is laden with combustible material, such as in flour or powder mills."—Loco.

OIL AND GREASE CUPS

FOLLOWING the squirt-can and grease-paddle methods of applying lubricants came the era when oil and grease cups were the most approved appliances for keeping bearings from running hot. These inventions relieved the attendant of the duty of constantly watching bearings and applying lubricants. Instead of applying the friction reducer every few minutes in over quantities the cups feed regularly just what is needed and not only keep the friction a constant quantity but by careful regulation a great saving in the amount used can be accomplished.

The great number of oil cups are caused to feed to the bearing, a drop at a time by means of gravity



DETROIT GLASS BODY PUSH PUMP

large bearings being supplied with 2 or more cups so that the oil will be distributed evenly to all parts of the bearing. An aid to the attendant is to have the body of the cup of glass so that the amount of oil in cup can readily be seen, also a sight feed arrangement in the shank is a convenience in regulating the flow. Where cups are apt to be struck, however, these conveniences are not always permissible and metal bodies without the sight feed must be employed.

Regulation is usually done by means of a needle valve with a locknut so located on the stem as to keep the adjustment constant, once it is properly set turning the oil off or on does not change the feed adjustment. Since the amount supplied to the bearing depends upon the viscosity of the oil the adjustment of the feed must be changed with changes in temperature.

For some bearings, such as crank pins, advantage is taken of the motion to drive piston valves which force the oil from the cup to the bearing. In others, such as loose pulleys, centrifugal force acts to drive the oil to the bearing.

To eliminate the personal element as far as possible oil cups used on bearings in motion are so constructed that oil is shut off automatically when not needed.

Grease cups are made of metal so arranged that by screwing down a thimble or thumb nut the grease is forced to the bearing. In many cups, however, the pressure on the grease is kept constant by means of a spring or air trapped in the upper part and compressed by screwing down the cap. Another style depends upon the heat of the bearing, conducted to the body of the grease in the cup by means of a rod, to melt the grease which flows by gravity to the bearing.

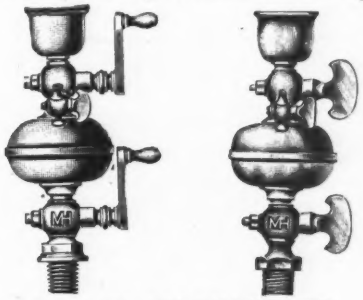
DETROIT HAND OIL PUMP

FOR forcing lubricating oil into the cylinders of large engines when they are being started, some sort of hand operated oil pump is most convenient. For this purpose and for similar uses where oil must be fed under pressure, the Detroit push pump has been developed. This type of pump with glass body is shown herewith, the pump, however, is made with glass or brass body. Most styles are equipped with reversible shank for either vertical or horizontal connection, the shank shown to the left and the plug at the bottom being interchangeable. The principal advantage of this pump is that there are no spring check valves.

GLOBE OIL AND TALLOW CUPS

GLOBE oil and tallow cups made by McNab & Harlin Mfg. Co., are shown herewith. These cups are used for lubricating cylinders under a vapor pressure and are operated as follows:

To fill the cups close the lower valve, open the pet cock and the upper valve of the cup. The lubricant poured into the funnel shaped top then runs down into the body of the cup. When full the upper valve



GLOBE OIL AND TALLOW CUPS

and pet cock are closed and the lower valve opened. This allows the oil to run by gravity to the cylinders, since the opening is large enough to allow the pressure in the cylinder to act upon the surface of the lubricant.

CHAMPION ROD OIL CUP

THE Champion Rod Oil Cup, shown herewith, is designed for lubricating crank pins and similar bearings. The shape of the cup is round and therefore when the engine is in motion the oil travels around

THE LUNKENHEIMER CHAMPION ROD OIL CUP

the cup in a circle. The body has a glass on each side to enable the engineer to see at a glance how much oil is in the cup, and the feeding arrangement consists of a tube, with a regulating valve at the top, screwed into the base of the cup and connecting with the oil hole in the tank.

When the engine is set in motion oil is thrown against the feeding apparatus and flows through it to the bearing. The oil hole in the feeding device being at the top of the cup, no oil will be supplied to the crankpin except while the engine is in motion.

20TH CENTURY AUTOMATIC LOOSE PULLEY OIL CUP

THE accompanying cuts illustrate the manner in which the principle of centrifugal force is used to oil loose pulleys automatically. The cup will run from 1 to 3 weeks per filling, according to the number of starts and stops, speed, etc. All oil put into the cup goes to the

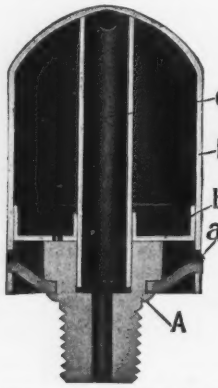


FIG. 1. SECTION OF TWENTIETH CENTURY LOOSE PULLEY OIL CUP

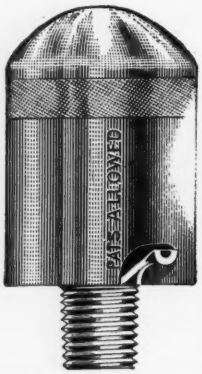


FIG. 3. OILER READY TO SCREW INTO PULLEY HUB

bearing and the nuisance of having oil flung and spattered over floor, workman, machine and belts is avoided with a decided saving in oil and time.

Figure 1 shows the inside and the feeding tube. When the pulley is brought into operation the centrifugal force throws the oil to the top of the cup and fills the feeding

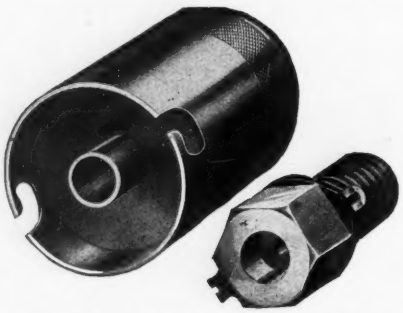


FIG. 2. PULLEY OILER DETACHED FROM THE NIPPLE

tube. When the pulley starts next time a portion of the oil in the tube is fed to the bearing and the tube again fills itself.

Figure 2 shows the cup detached from the nipple for filling. This can be done easily with the hand, no wrenches being required. The cup can be removed, filled and replaced with the pulley in any position, thus doing away with the necessity of shifting belts, turning shafting, etc., to bring the oil hole on top.

This cup is made of thin pressed steel and is so light that counterbalancing is not necessary. It is, however, amply strong, as there are no moving or wearing parts. It is manufactured and sold by the American Specialty Co., Chicago.

POWELL OIL AND GREASE CUPS

THE Signal Oiler is of the lever-up, lever-down, sight feed type, in which the feed can be stopped or started instantly without disturbing the regulation, which is adjusted by the milled nut R. The jam nut O securely locks the regulation and the swinging lever S covers the filling hole, keeping dirt and dust out of the oil. When the signal lever C is up the oiler is feeding, when down it is closed, and when at an angle of 45 deg. it is flushing the bearing.

The improved automatic grease cup, Bear, is constructed with a flexible, yielding cup leather plunger that operates with a minimum friction and is tight under all pressure within the range of the actuating spring which drives the plunger. The plunger packs

FIG. 1. SIGNAL OILER.

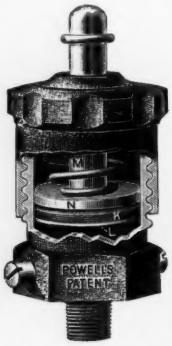
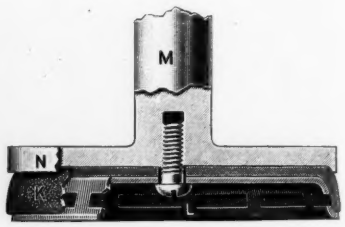


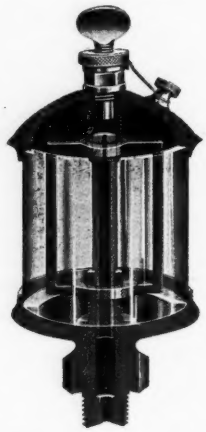
FIG. 2. IMPROVED ALL-IRON COMPRESSION GREASE CUP BEAR AND CUP LEATHER PLUNGER.



tight with all grades of grease and especially with soft or semi-fluid greases.

IMPROVED AUTOMATIC CRANK PIN OILER

THE crank pin is another place where considerable ingenuity and scheming has been resorted to, to keep this bearing lubricated at all times and free from excessive temperature. In the illustration is shown an improved automatic crank pin oiler, designed by the Sherwood Mfg. Co. In this device the feed is adjusted by turning the regulating stem to which is at-



IMPROVED AUTOMATIC CRANK PIN OILER

tached a lock nut to secure the stem when properly adjusted. The construction of the cup is such that it will feed on high or low speed engines. The valve

gives a stroke at each revolution of the crank and when the engine stops the valve drops to the bottom and closes the outlet, stopping the flow of oil automatically.

THE SWAIN LUBRICATOR

THE Swain lubricator consists of a metallic tube, a tight fitting cap, an indicator rod with weight attached, which shows the amount of lubricant in the tube, and a lubricating candle. The lubricant which is

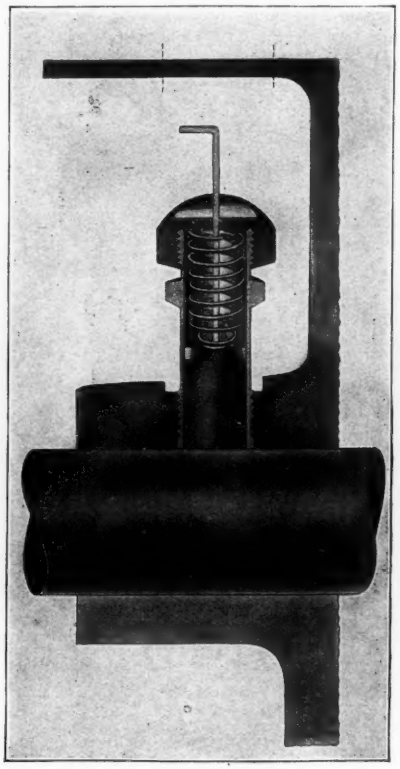


FIG. 2. SWAIN LUBRICATOR APPLIED TO LOOSE PULLEY

a candle made of asbestos, graphite or mica in various sizes and degrees of hardness to suit the requirements kept in direct contact with the revolving shaft and is worn only while the machinery is in operation.

The Swain lubricator for loose pulleys is similar in construction to that just described with the exception of a light coil spring which is inside the metal tube for the purpose of keeping the lubricating candle pressing constantly against the journal. This method insures a perfect and uniform feed, and is very satisfactory for lubricating loose pulleys.

SAFETY CRANK-PIN OILER

THE crank-pin oiler made by the Swift Lubricator Co., has a tightly closing valve on the cover which prevents waste of oil. By means of the regulating screw at the top, shown in Fig. 0, the feed is increased or diminshed as desired. The hollow plunger provides 2 feeds, a force feed from the bottom of the cup, and a flush feed from the top. The regulating screw is packed in the same manner as the stem of a globe valve, and can always be kept tight. When the engine is stopped the cup does not require to be shut off as the plunger keeps at the bottom of the cup and the oil will not flow except when the engine is running.

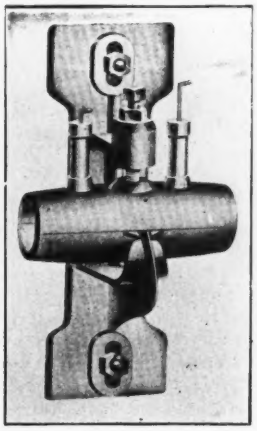


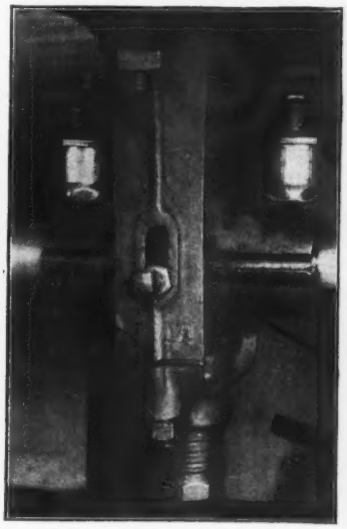
FIG. 1. SWAIN LUBRICATOR ATTACHED TO SHAFT BOX

PHILADELPHIA COMPRESSED AIR GREASE CUP

GREASE manufacturers have been hampered to a large extent in the past by the lack of proper appliances for feeding the grease.

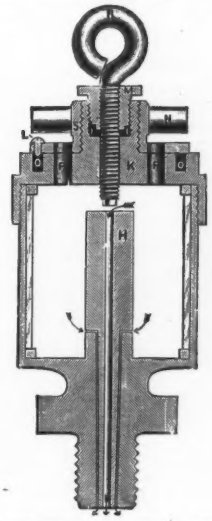
Because of the non-fluidity of the grease in the large majority of cases, the same automatic feeding cannot be obtained as with oil, where the amount necessary to keep the bearing supplied can be adjusted to a nicety.

Various appliances, such as hand compression cups, spring compression cups and force feed cups have been

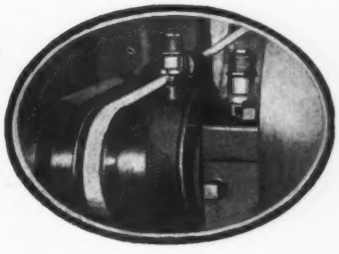


PHILADELPHIA CUP ON SHAFT HANGER

in use with more or less success. It stands to reason, however, that any appliance of this kind that depends upon hand regulation must be unsatisfactory where the



SECTIONAL VIEW OF SAFETY CRANK PIN OILER



PHILADELPHIA CUP ON AN ECCENTRIC

same amount of lubricant is not required by the bearing at all times. If the bearing does not get enough, there is friction; if it gets too much there is waste of grease. Spring compression keeps forcing the grease

on the bearing, whether it needs it or not, and the mechanical pressure has a tendency to force the free oil out of the grease first. This pressure is greatest when the cup is full, as the spring is compressed to its utmost; as the grease descends in the cup it constantly becomes harder, while the spring lengthening out naturally becomes weaker.

Experience has demonstrated that to get the best results from grease just enough pressure must be applied to keep the grease where the journal can get it as needed. In other words, the feeding force must be elastic, and compressed air supplies this quality.

The Philadelphia compressed air grease cup, which uses compressed air in an effective manner, consists of 2 parts, the one screwed into the other; the lower half is threaded on the inside and the upper half on the outside. From the center of the upper half is suspended a thin metal disk, which rests lightly on the grease, but is in no sense a plunger, its only function being to keep the grease level, as the pressure back of it is exerted on the grease by the air entrapped in the upper half of the cup.

The lower half of the cup is filled level full of grease, care must then be exercised to see that the metal disk swings loosely from its attachment in the cup; it is then laid lightly on the grease and the upper half screwed into the lower half about quarter way. The air contained in the upper half of the cup has thus been compressed about 25 per cent, because the moment one-half of the cup is started to screw into the other half, the entrapped air forces the grease into the threads, and this acts as a perfect seal.

The air seeking to expand to its original size is what causes the grease to feed, aided by the suction of the journal as it requires more lubricant. This feeding force is so elastic that should the top be screwed in too far at the start, or too often while running, it will not force more lubricant on the bearing than is necessary, for as the journal is harder and the grease of greater density than the air, the air has to yield, and is simply compressed to greater density. This cup, which is made by the Universal Lubricator Co., of Philadelphia, feeds steadily in any position; it may be placed even upside down.

WILLIAMS OIL CUPS

TACOMA Oil Cups are of the sight-feed type and are adjusted by turning the upper curled nut, which, when once set is firmly held in place by the curved spring. The most important feature is the

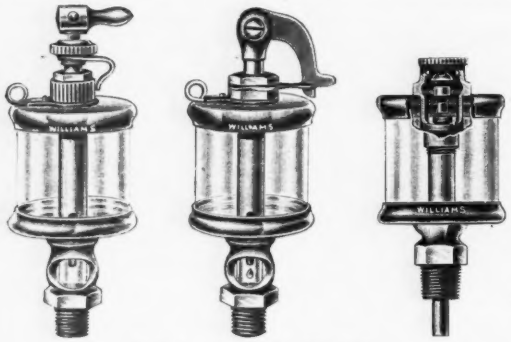


FIG. 1. TACOMA OIL CUP
FIG. 2. TOPAZ INDEX GLASS OIL CUPS
FIG. 3. NEEDLE VALVE FEED AUTOMATIC ROD OIL CUP

snap lever at the top. Raising or lowering this lever opens and closes the feed instantly without disturbing the adjustment, this enables the operator to secure the same rate of feed any time after the oil has been cut off without any re-adjustment.

In the Topaz sight-feed oil cup, the feed is regulated by the indicator lever attached to the stem, and when the desired feed is obtained it is lowered and locked in the forked index lever beneath. This lever has several depressions in that part of the periphery forming a bearing between 2 adjustable lock nuts which grip it sufficiently to hold it at any angle to which it may be set. When the feed is cut off, the

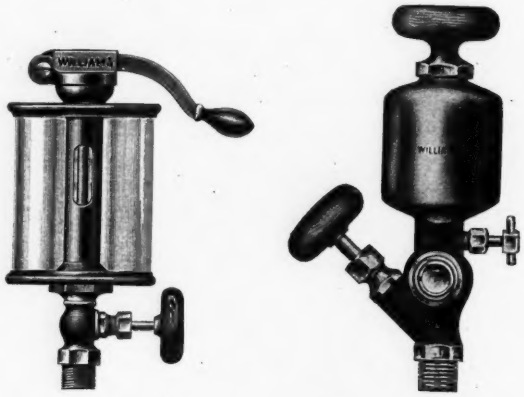


FIG. 4. WALRUS GLASS BODY OIL PUMP
FIG. 5. WONDER GAS ENGINE LUBRICATOR

curved indicator lever can be left standing up out of the notch, indicating at a distance that the feed is closed.

Williams autoamtic rod oil cup with needle valve feed is regulated by turning the set screw which controls the lift of opening of a small check valve immediately beneath. The adjustment is made with an ordinary screw driver, and when once regulated no further attention is necessary.

The mechanism of the Williams Walrus glass body oil pump is located inside of the collar at the bottom of the reservoir, and being completely submerged in oil it can be easily operated at all times. To prevent dust from being fed into the engine by this pump, a dust proof cover is provided which fits snugly over the lever on to the filling hole and a strainer is placed at the bottom of the reservoir, over the oil supply holes which prevents any grit or foreign matter in the oil from finding its way into the cylinder.

The Wonder lubricator is designed for use on gas or gasoline engines and air compressor cylinders. The feed is regulated by the tee handle valve, and the flow of oil is observed through the bull's eye sight glass in the shank.

F. B. DEGRESS, for over 10 years New York district manager of the Crocker-Wheeler Co., has resigned from that company to assume the position of general sales manager of the Pulsometer Co., 17 Battery Place, New York City. Besides looking after the sales end of the business, Mr. DeGress is also carrying on a series of experiments, with a view to improving certain features of the Pulsometer in order to make it suitable for general pumping work in power plants, industrial establishments, etc., so that it may become as popular for this class of work as it is in the general contracting field where it is now used.

HYDROSTATIC LUBRICATORS

AUTOMATIC lubrication of steam cylinders was first accomplished by means of hydrostatic lubricators. These are placed on the steam pipe leading to the engine or pump on the boiler side of the throttle valve where the pressure on the lubricator is kept as nearly even as possible.

The principle of operation is, steam from the main pipe is allowed to condense in a condensing bulb and connecting pipe where a head of water of about 2 ft. is formed. This is so applied under the body of cylinder oil in the lubricator that the oil is forced through a regulating valve and sight-feed glass into the steam pipe. Here the oil is atomized by the steam rushing to the cylinder and so thoroughly mixed with the steam that it covers the wearing parts of the valve and cylinder surface.

There are in common use 2 methods of connecting the lubricator to the steam pipe, known as the double and single connection. In the double connections, the condensing bulb has a pipe connected to the steam pipe about 2 ft. above the connection which carries the oil to the inlet, while in the single connection, one pipe only is attached to the steam pipe. The condensing loop, which extends about 2 ft. above the lubricator body is lead off from this connection which supplies it with steam and the oil is carried into the steam pipe by the same connection. In exposed places, the single connection is the one commonly employed since the steam from the supply pipe keeps the lubricator and oil warm, thus preventing low temperature from interfering with the operation of the device.

THE DETROIT SIGHT FEED LUBRICATOR

BY reference to Figs. 1 and 2, the details of the operation of the Detroit sight-feed lubricator can easily be understood. The pipe P connects with a passage from the condenser A2, so that as soon as the water

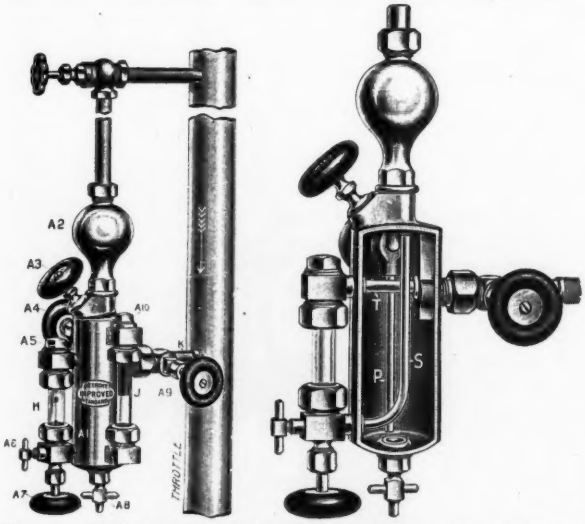


FIG. 1. THE DETROIT SIGHT-FEED LUBRICATOR ATTACHED TO PIPE

FIG. 2. SECTIONAL VIEW OF THE DETROIT SIGHT-FEED LUBRICATOR

feed valve A4 is opened, the water in the condenser will pass down the pipe P, to the bottom of the body of the lubricator, and being heavier than oil will stay at the bottom, the oil floating at the top. The pipe S leads to the lower sight-feed arm, from the upper part of the body of the lubricator. The body A1, being filled with oil, the steam from the main steam pipe passes in the condensing pipe above the lubricator, and condenses, filling the condenser and part of the pipe above it with water. Steam also passes into the support arm and through the internal tube T, into the sight-feed glass where it condenses, filling the glass with water.

As soon as the valve A4 is opened, the oil in the body of the lubricator is subjected to the pressure of the column of water extending up through the pipe P,

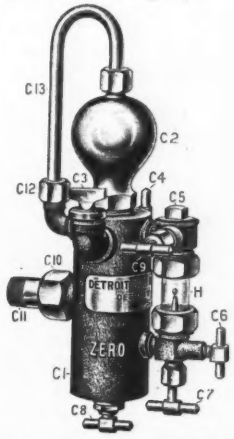


FIG. 3. THE ZERO LUBRICATOR

the condenser and part of the pipe above it, amounting to about 2 lb. per square inch. This difference in pressure between the upper and lower connection to the steam pipe forces the oil down the pipe S, and through the valve A7, to the sight-feed glass where the amount of oil is regulated by the valve A6. Passing through the sight feed the oil is forced by the head of water through the pipe T, to the steam supply pipe to the pump or engine.

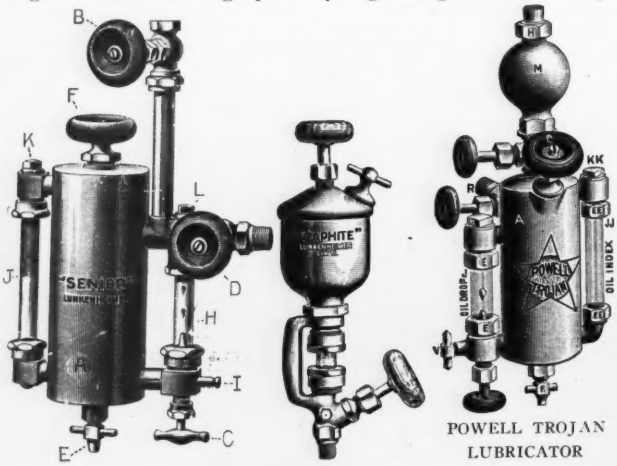
Another form of sight-feed lubricator made by the same company is the Detroit Zero which has a single connection to the steam supply pipe. The operating principles of this lubricator are practically the same as for the one just described, except that in the Zero lubricator, which was designed particularly for traction engine service and engines working in exposed places subject to changes of temperature, the oil is kept warm by steam. This heating arrangement is automatic, and so long as steam is supplied to the engine, the oil will be kept warm.

LUNKENHEIMER LUBRICATORS AND OILERS

IN the improved senior sight-feed lubricator, the Lunkenheimer Co. has dispensed with the condensing chamber or bulb, owing to its liability to freeze and consequent bursting. The filling plug has been placed directly on top of the oil reservoir or chamber, which makes the cup easy to fill. By the provision of a vent plug, the sightfeed can be blown out with steam to clean it. This lubricator has a double connection to the steam pipe and operates on the hydrostatic principle.

The automatic sight-feed graphite lubricator has been developed for use on cylinders of steam engines and pumps being placed on the steam chest. On slide valve engines it is necessary to use only one cup, placing it about the middle of the steam chest, but on Corliss engines it is best to use two, placing one over each valve. To operate the cup, close the steam valve and open the drain plug to allow steam to escape from the

cup; then close regulating valve, remove filling plug and fill the cup with graphite. After replacing the filling plug, close the drain plug, open the steam valve wide and regulate the feed of graphite by regulating valve.



POWELL TROJAN LUBRICATOR

FIG. 1. IMPROVED SENIOR SIGHT-FEED LUBRICATOR
FIG. 2. LUNKENHEIMER AUTOMATIC SIGHT-FEED GRAPHITE LUBRICATOR

The Lunkenheimer gas engine multiple oilers designed for the lubrication of cylinders and bearings of vapor engines is shown in Fig. 3. This oiler is of the sight-feed type, with snap levers which may be adjusted independently and allow the operator to see the oil fed to any part of the engine.

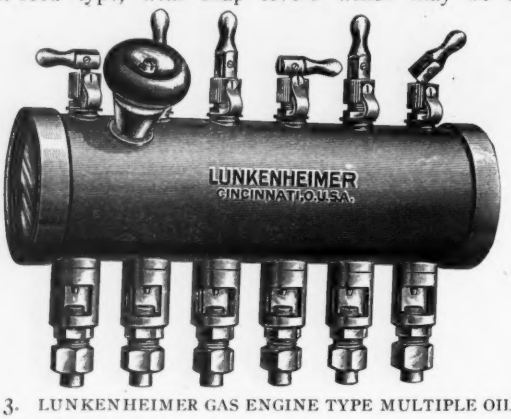


FIG. 3. LUNKENHEIMER GAS ENGINE TYPE MULTIPLE OILER

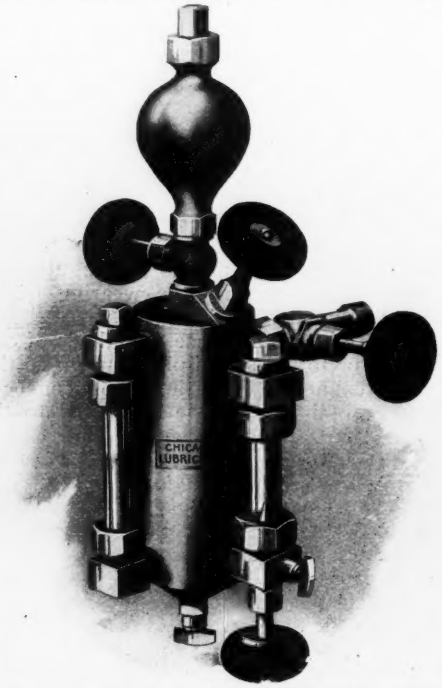
All these sight-feeds are fitted with check ball, baffle cap and equalizing tube and they can be connected either for cylinder or bearing lubrication.

POWELL TROJAN LUBRICATOR

THE Trojan lubricator works on the hydrostatic principle with double connection to the steam pipe. The body shell is cast in one piece, which insures positive feed and perfect lubrication under severe conditions, as the arms cannot get out of line and there are no joints to loosen or leak. The oil is poured directly into the reservoir A, through the filling hole B.

THE CHICAGO DOUBLE CONNECTION SIGHT-FEED LUBRICATOR

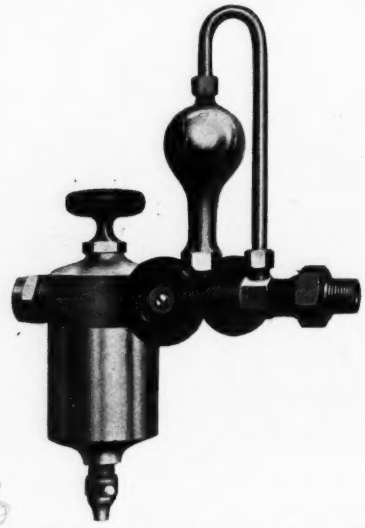
THE Chicago double connection sight-feed lubricator, made by the Ohio Injector Co., is especially intended for stationary engines, and is provided with an ample heating chamber which insures the oil remaining fluid even when exposed to extreme cold weather. The condenser valve is a separate piece, which makes cleaning the lubricator an easy matter. The lower feed arm is provided with a drain stem by which the sight feed may be blown out and cleaned without removing from the lubricator. The lubricator works on the hydrostatic principle.



THE CHICAGO DOUBLE CONNECTION SIGHT-FEED LUBRICATOR

THE SWIFT SINGLE CONNECTION SIGHT-FEED LUBRICATOR

FOR use where it is desirable to attach with only one connection to the feed pipe, the Swift single connection sight-feed lubricator has met with excellent results. It is so constructed, that it will feed any oil, no matter how heavy, even in exposed positions in cold weather. This lubricator is designed to be connected to the steam pipe between the throttle valve of the engine or from pump and the boiler.



THE SWIFT SIGHT-FEED LUBRICATOR, SINGLE CONNECTION

OIL PUMPS

ECONOMY in the use of lubricants demands that the bearing be supplied with just enough of the lubricant as is necessary. This quantity depends somewhat on the manner in which the lubricant is applied. While a drop of oil, fed by means of a sight feed oil cup, may be sufficient to keep the bearing well lubricated for several seconds, it is evident that during the first part of this period the bearing is better lubricated than during the latter part.

To secure best results it would seem necessary to feed the oil continuously in just such a quantity as is required. Since it is impossible to divide a drop of oil up into small particles by sight feed alone, the method most generally employed in power plants today is by means of oil pumps. In general, oil pumps are so constructed that the amount of oil being used on each bearing can be seen, that is, each feed is supplied with a regulating valve which allows the oil to drop in plain view to the pump so that the number of drops used a minute can be counted.

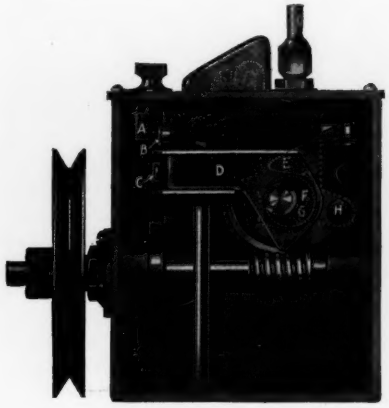


FIG. 1. SECTIONAL VIEW OF DETROIT FORCE FEED OILER

From the sight feed, a plunger pump, operated from some moving part of the machine, drives the oil to the bearing in fractions of a drop. This gives the bearing a continuous supply in just such a quantity as required and all waste is thus avoided.

The saving effected by the use of oil pumps is particularly noticeable in the case of cylinder lubrication, where, by the ordinary hydrostatic method, a great share of the lubricant is bound to be thrown out with the exhaust. When pumps are employed, however, a constant quantity is being fed at each stroke of the piston and this is usually carried directly to the bearing surfaces by oil pipes, thus not only securing an economical use of the lubricant but distributing it to all parts of the cylinder as required.

Where flush lubrication is employed, force-feed oil pumps give most positive service as in this case a separate plunger is employed for each bearing and it is possible to feed different grades of oil to the different bearings.

With oil pumps operated from some moving part of the machine no matter how variable the speed of the machine the oil is fed in proportion to the speed and changes of temperature or grade of oil do not affect the regular and positive feed of oil.

DETROIT FORCE-FEED OILERS

THE Detroit force feed oiler consists essentially of one or more pumping units, one unit to each feed, actuated by a driving shaft. The entire mechanism is contained in the tank or reservoir. Each pumping unit consists of a double plunger valveless pump, one plunger being used to pump the oil from the reservoir through the sight-feed nozzle from which it drops in plain sight, so that the exact amount of oil being fed to any part of the machine can be seen, and the other plunger takes the oil from the sight-feed chamber, under the nozzle, and forces it to the part to be lubricated.

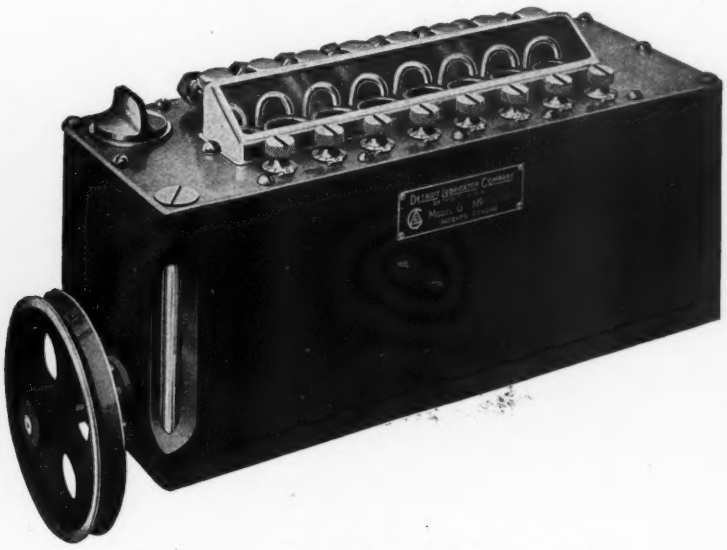


FIG. 2. EIGHT-FEED DETROIT FORCE FEED OILER

In operation the upper piston B, Fig. 1, driven through a bell crank yoke E by the eccentric G, lifts the oil from the reservoir and discharges it from the nozzle N. The amount of oil discharged is regulated by the adjusting button on cover, this button having at its lower end the cam A, which controls the throw of the piston B. The lower plunger C takes the oil from the pocket in the sight-feed chamber under the nozzle N and forces it to the point to be lubricated through the tube O.

This forcing plunger C is driven by the eccentric F, through the yoke D. The bell crank yoke E and the straight yoke D give to the piston an alternate movement, each being substantially at rest while the other is passing through its 90 deg. of most rapid travel. A port in each piston controls the passage to the other, so that each becomes, without additional mechanism, a mechanically operated valve for the other.

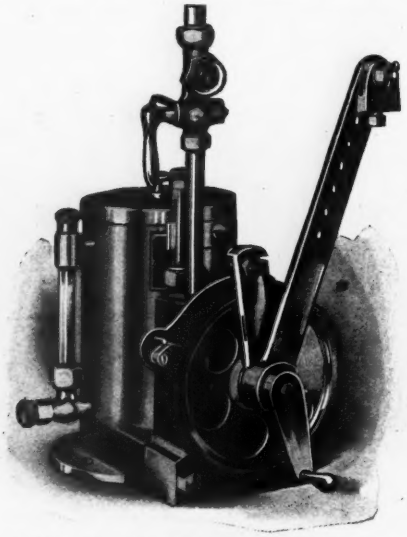
The eccentric G is driven by the eccentric F, and when the engine is working ahead it is in the same position as the eccentric shaft. When the engine is reversed, however, the eccentric G remains stationary until F has advanced 180 deg. in the opposite direction, where it is again picked up and driven in the new direction by F.

In Fig. 2. is shown an 8-feed Detroit force feed oiler, with special left end pulley drive and tubular gage glass.

THE ROCHESTER AUTOMATIC LUBRICATOR

DUE to the fact that the Rochester automatic lubricator is a positive feed, there is always a solid column of oil under pressure from the lubricator to the point of delivery. Also due to this cause, the temperature makes no difference on the feed, as the same amount of oil will be pumped regardless of whether it is thick or thin. The amount of oil fed can be regulated by 3 distinctly different methods, so that the lubricator will feed anywhere from a fraction of a drop to an almost continuous stream.

There is a double set of ball valves that prevent the clogging of the lubricator, and each feed of the lubricator is provided with a 3-way cock and a patent combination Multiplus Sight Feed, which shows the oil passing to its destination as well as the amount being fed. The maker of this pump is Greene Tweed & Co.



SINGLE FEED ROCHESTER LUBRICATOR

THE MANZEL SIGHT-FEED OIL PUMP

ADJUSTMENT of the feed in the Manzel oil pump is made by screwing the feed regulator in or out to feed the amount of oil desired. This can be done without stopping the engine or pump, and each feed is regulated independently. The pump is of the double plunger type, the lower plunger drawing the oil out of the reservoir and forcing it through the sight glass, the upper plunger forcing it into the steam cylinder, the supply of oil being adjusted by means of the feed regulator. The entire pump mechanism is inside the reservoir and works in oil.

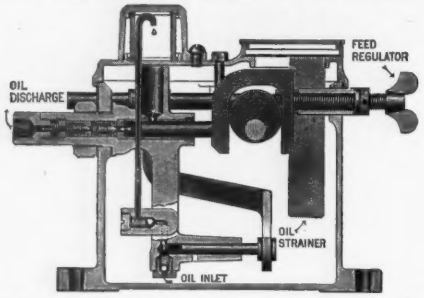


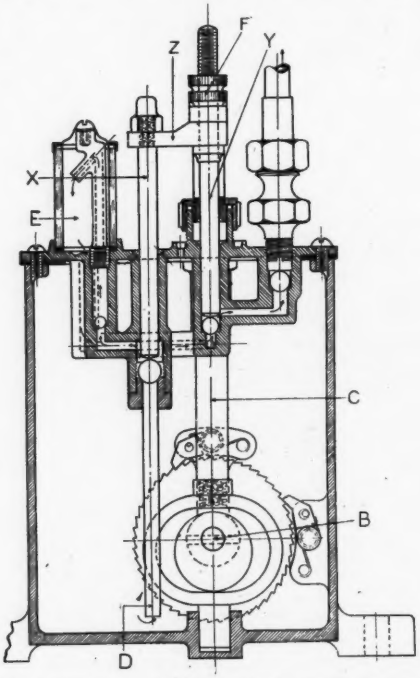
FIG. I. SECTIONAL VIEW OF THE MANZEL PUMP

Other features of the pump are the provision of a gage glass to show the amount of oil in the reservoir, and a hand attachment for use before starting the engine, or if more oil is needed at any time while the engine is running. The sight-feed attachment is on top of the pump, as shown in the illustration of the 4-feed type, Fig. 2, and the oil drops unretarded through an air space to a cup from which it is forced through separate connections to each bearing surface.

FIG. 2. FOUR-FEED MANZEL FORCE AND SIGHT FEED OIL PUMP

McCORD FORCE-FEED LUBRICATORS

THE McCord Class B lubricator, made by the McCord Manufacturing Co. of Detroit, is especially designed to give a positive delivery of oil and the exact amount required, direct to the bearing where it is needed. It is automatic, being mechanically driven from the engine, pump or machine which it is lubricating and consequently starts and stops delivering oil and changes the quantity delivered entirely in accord with the action of the lubricated engine or machine.



SECTIONAL VIEW OF M'CORD FORCE FEED LUBRICATOR

The lubricator consists of a cast-iron reservoir containing pumps, the number of which varies with the number of oil feeds desired. These pumps are operated by an eccentric running in oil and driven by an outside

lever through a ratchet mechanism, also entirely immersed in oil. As previously stated, there is one pump for each oil feed, or, to be more exact, there are 2, as each complete pump consists in reality of 2 plungers, each an individual hydraulic pump, though both operate together. These plungers may be designated as the primary and delivering plungers. A glance at the sectional view accompanying this article will show how these are placed in the cast pump body, which is suspended through the reservoir cover.

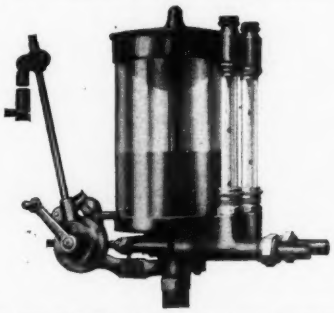
The primary plunger, and the secondary or delivery plunger, Y, are connected by the yoke Z, which is moved up and down in a vertical position by the shaft C, which in turn is driven by the eccentric B. On its upward stroke the primary plunger X draws the oil from the bottom of the reservoir past the first ball check valve shown, and on the downward stroke passes it up through the sight feed. After dropping down from this sight-feed nozzle, it is in turn drawn by the upward stroke of the secondary plunger Y, and on the downward stroke driven out through the connection shown, to the lubricated part. The adjustment of these pumps is entirely regulated by the stroke of the plungers and is readily and quickly accomplished by changing the set screw F, shown just above the driving yoke Z.

Each of the plungers is tested up to 1000 lb pressure, all exposed parts of the lubricator are heavily nickel-plated and all moving parts on which there could be any wear are constantly running in oil.

THE HART FORCE-FEED OIL PUMP

PACKED piston plungers are used in the Hart force sight-feed oil pump, made by the Sherwood Mfg. Co., and shown herewith. The oil is forced to the sight-feed glass through the regulating chamber and a surplus supply of oil is at all times held in the regulating chamber under pressure.

Check valves are provided to prevent any back pressure on the pump, and no steam or water reaches the sight-feed glass which is always at atmospheric pressure. The sight-feed glass is of such size and so located that it can easily be cleaned and will not cloud. The pump



HART FORCE SIGHT-FEED OIL PUMP

is for use on valves and cylinders of all styles of engines or pumps or any place where lubrication is required against pressure.

STERLING LUBRICATORS

THE main shaft of the Sterling lubricator, a cross section of which is shown in Fig. 1, passes through the entire body of the lubricator, and the rocker shaft, nearly through. This gives both shafts long bearings, and gives these 2 working parts strength.

The rocker permits of a large range of discharge per stroke of the pump, and any pump may be quickly and independently adjusted, from no stroke to full stroke, or any intermediate point without disturbing any other adjustment, and the graduations on the rocker enable one to ascertain at a glance just how much oil any pump is feeding. A hand attachment upon the driving wheel permits operation of the lubricator, while the engine or machine is at rest, as before starting or in case more oil is needed momentarily, while the engine or machine

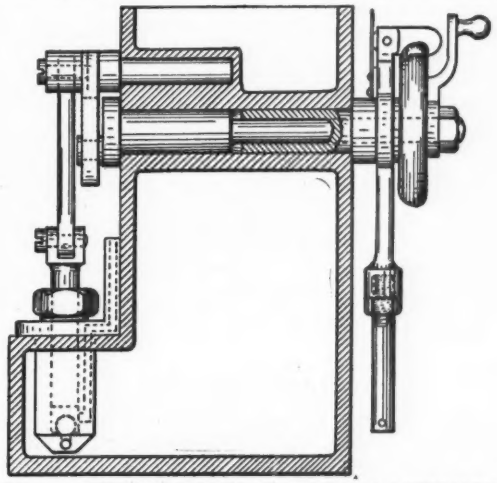


FIG. 1. SECTIONAL VIEW OF STERLING LUBRICATOR

is in motion, and its use does not disturb any of the adjustments. The check valve is so constructed as to prevent back pressure of steam, gas or air, and to prevent the vacuum in the cylinder of a condensing engine from siphoning the oil out of the lubricator.

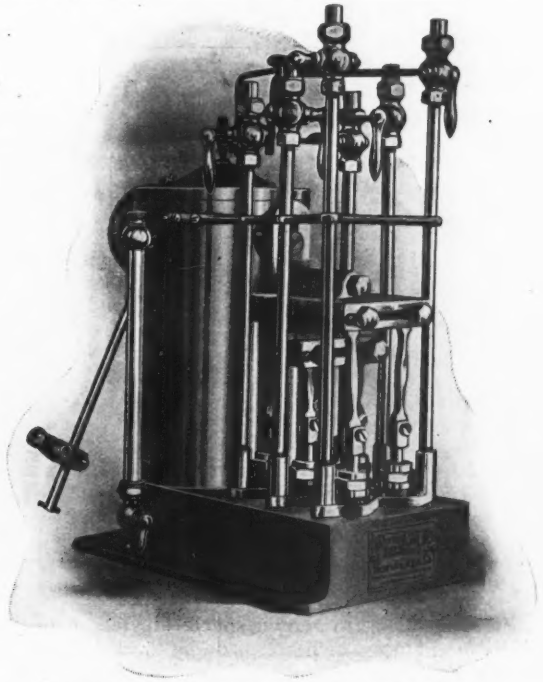


FIG. 2. SIX-FEED STERLING LUBRICATOR

The 6-feed Sterling lubricator has the same operating principles as the one just described. The plungers are arranged in 3 sets of twos, so that the 2 back and 2 front plungers are adjusted from the back and front of the rocker, while the 2 center plungers are attached to the under side of the rocker. This lubricator is made in 2 compartments if desired, so that 2 grades of oil can be fed at the same time.

OILING DEVICES

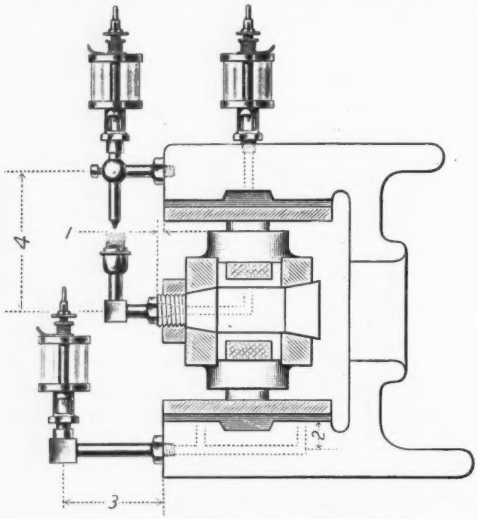
FREQUENTLY the ingenuity of the designer is taxed in devising some means for keeping moving bearings constantly supplied with lubricants. On crank pins it is common to use a tube so placed that it revolves with the crank but has a cup in the center line of the shaft. Oil fed into the cup by any convenient means is driven to the crank by centrifugal force. Eccentric straps may have long open cups into which oil is dropped from some feeding device.

Cross head pins are frequently supplied with telescope tubing that conducts the oil to the bearing. The wick wiper is also a common means for furnishing oil to the crosshead.

A great many other devices have become commercial products and they all have for their object the feeding of a regulated amount of oil without waste direct to the bearing surface, frequently feeding several bearings from the same reservoir.

OILING DEVICES

IN order to keep the various parts of an engine well lubricated by the use of sight-feed oil cups, many schemes have been resorted to. That shown in the accompanying illustration, is the method devised by the Detroit Lubricator Co., for oiling the guide and cross-



DETROIT CROSSHEAD OILING DEVICE

head of an engine. This requires the use of 3 sight-feed oil cups, one for each guide, the other feeds the crosshead pin by means of a wiper.

LUNKENHEIMER IMPROVED OILING DEVICES

IN Figs. 1 and 2 are shown special devices for oiling parts of engines which are made by the Lunkenheimer Co. In Fig. 4 is shown a device for oiling a pillow block, 2 eccentrics and crankpin from one oil cup. The sight-feeds aid in the regulation of the amount of oil going to each bearing which can be done independently.

The "H-W" crosshead pin oiler for horizontal engines is shown in Fig. 2. In this device the oil is fed by gravity from a cup into the funnel at the center of the oil tube. It then overflows through small holes in the top of the tube, enveloping the outside of the tube with a thin film of oil. The wiper cup, being attached to the pin, travels directly under the tube. As the crosshead travels to the left, the tongue to the right scrapes the oil off the bottom of the tube and the

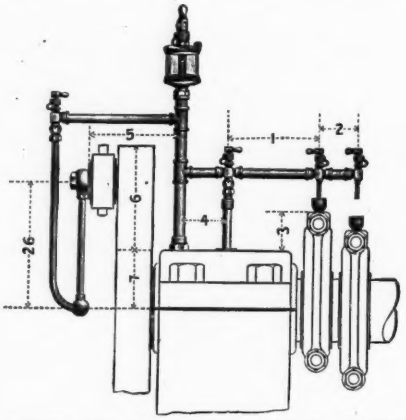


FIG. 1. LUNKENHEIMER PILLOW BLOCK, ECCENTRIC AND CRANK PIN OILING DEVICE

reverse motion of the crosshead throws this tongue down, but as the 2 tongues are directly connected, the left hand tongue is thereby thrown in a vertical posi-

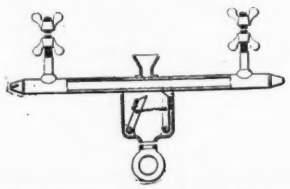


FIG. 2. LUNKENHEIMER "H-W" CROSSHEAD PIN OILERS

tion, and, in turn, scrapes the oil off the tube. The oil is then fed under a head of a few inches to the crosshead pin.

"IN ORDER to satisfy themselves as to the working of an oil, most engineers open the cylinders at intervals and note the condition of the surfaces. Satisfaction is generally felt if they find the inside of the cylinder polished like silver, or if it has a bright smooth surface, 'like a mirror,' as some express it. Now, this is not by any means the condition the cylinder ought to be in, if it be well lubricated with oil alone. Suppose an engineer found on opening the cylinders of his engines, that bright streaks existed, he would conclude at once that the bright spots were the result of friction; strange to say, if he found the whole surface of his cylinder polished, he would not think it was friction.

"A well lubricated cylinder ought to present a rather dark looking surface, smooth, but with no signs of bright polish, even if coated with oil. The slightest rubbing with a polishing rag would produce a bright surface on such a cylinder, thereby proving that the lack of polish is due to the absence of friction."—Cylinder Oil and Cylinder Lubrication.

FOR STEP BEARING OIL for steam turbines, the gravity has been found to run from 24.5 to 31.2; the viscosity from 54 sec. at 150 deg. to 228 sec. at 100 deg.; flash test from 334 to 445 deg., and fire test from 425 to 480 deg. As it comes from the bearing the oil is so hot that it has to be cooled and is mixed with as high as 40 per cent of water, which, unless time be allowed for settling, is carried into the bearings.

REUSING OIL

MINERAL oil of proper consistency for the service loses practically none of its lubricating value by being re-used, the fact has been proved many times by lubricating engineers, and consequently the modern power plant is equipped with apparatus for catching and purifying used oil.

The impurities gathered by the oil in its passage through a bearing are: grit and dust picked up in the oil tubes and housing of the box; particles of iron rust and metal from the bearings; and water usually condensation from steam leaks.

The purifying system commonly employed in power plants consists of some means for catching the used oil from the bearings and draining it to a filter where the impurities are removed, the purified oil being delivered to the storage tank for reuse. In small plants, however, a piping system is not employed, the used oil being caught in a bucket or can and poured into the filter by hand.

Oil filters are so arranged that the oil is passed through a series of screens, settling chambers and filter beds until it has been restored to its original purity. Filtering materials vary in different makes, those commonly employed being: excelsior, mineral wool, moss, waste, hair, sponge, charcoal, bone black, Fuller's earth, etc. In the settling chamber it is quite common to use water through which the oil is passed in finely divided particles thus allowing the particles of foreign matter to separate themselves from the oil and settle to the bottom of the chamber. Here too the water which has been caught with the used oil will settle while the oil floats on the surface.

The settling process is sometimes aided by heating the oil and water in the settling chamber which divides the oil into smaller particles thus giving the solid particles a better chance to separate themselves.

Another means employed for removing foreign matter from oils is the use of a separator similar to a cream separator. This process, however, has not been perfected for commercial use but has been used with considerable success in laboratories.

Centrifugal force is, however, employed in some machines for hurrying the filtering process with good results.

Another source from which oil may be reclaimed is the waste which is used to wipe up machinery and oil drippings. In some plants this dirty waste is put through a press which effectually squeezes the oil out. Another method employed is to place the waste in a basket which is rotated at a high speed, the oil being thrown out of the waste by centrifugal force.

Reclaiming cylinder oil has not been brought to perfection as yet but there are filters in commercial use which purify used cylinder oil caught in separators to such an extent that it can be used on bearings. The great difficulty encountered here is that the oil usually undergoes a change in composition owing to the emulsification of the animal constituent which is employed.

REPORTS FROM central stations show that for engines using superheated steam, cylinder oils are giving satisfactory service that have viscosity from 145 to 240 at 212 deg., flash point, 531 to 660 deg., and fire test 615 to 700 deg. The gravity runs from 24.5 to 26.8, Baume. Care should be taken to avoid those having an asphalt base which tends to carbonize in the cylinders.

PROPERTIES OF USED LUBRICANTS

PROPERTIES OF USED LUBRICANTS

SINCE the advent of mineral lubricants, simple methods for recovery and regeneration of used oils from all kinds of machines have been the s of effecting very considerable savings in the cost of lubrication. Oils of animal and vegetable origin undergo in use, in addition to the changes manifested in mineral oils, an oxidation which alters their properties. Their regeneration demands, in most cases, in addition to the filtration necessary for the recovery of oils of all classes, special chemical treatment of considerable cost and doubtful economy.

In the case of mineral lubricants, on the other hand, it is necessary in the majority of cases only to filter carefully in apparatus of the ordinary commercial types, or at most to supplement the filtration with treatment by steam under pressure followed by simple decantation, to obtain a product of properties approximating those of the original oil.

The extent to which the properties of lubricants are modified by use, and the efficiency of regeneration by filtration, have recently been investigated in the testing laboratory of the Conservatoire National des Arts et Métiers, in Paris. Six different samples of oil were tested for density, flashing and burning points, viscosity, index of refraction, color, acidity, saponification value, fat content, and coefficient of friction, before and after use for the lubrication of a shaft bearing, a gas-engine cylinder, a steam-engine cylinder, a piston rod, a main engine bearing, and an electric motor. The tests subsequent to use were made after filtration of the oils in commercial filters followed by a supplementary filtration in the laboratory.

Results support the conclusion of other investigators, that use slightly increases the density of lubricants, because of the volatilization of a part of the volatile constituents. Both the flashing and burning points are raised by some degrees. The viscosity, in general, remains about the same. No change in acidity is apparent, even in the case of a lubricant consisting of a mixture of a mineral and a vegetable oil, used in a gas-engine cylinder, in which use reduced the percentage of the fatty oil from 19.3 to 17.5 per cent, indicating a complete destruction of a part of this constituent.

As to the coefficient of friction, the curves of the results of the mechanical tests, which were carried out on the Martens oil-testing machine, show no variations between the values before and after use outside the limits of possible error of observation. It seems entirely reasonable to conclude, therefore, that a used lubricant, recovered under proper conditions and carefully filtered to remove matter in suspension, preserves practically unchanged its original properties.

BOWSER OIL FILTERS

Being designed for hand use only the 5-F type outfit should not be used for oiling system. It is arranged for dumping in batches of oil so it can stand and settle water. The water is then drawn off before opening to the filter. The pump takes the oil from the filtered compartment and the nozzle drips return to the dirty oil compartment.

This equipment has a capacity of 35 gal. for dirty oil and 85 gal. for clean oil. It is fitted with a hand pump.

Figure 2 shows the highest grade oiling system which is made by S. F. Bowser & Co. With this system any tank may be shut down and cleaned without interfering with the regular operation of the system. Two pumps are furnished for elevating the oil to the gravity tank, either one of which is amply able to meet the most excessive demands; automatic pump

FIG. 1. BOWSER 5-F TYPE FILTER

governor, 2 hand pumps and arrangements for saving even the dirty settlings.

This system is made with from 2 to 10 large filter sections with a normal filtering capacity of 20 gal.

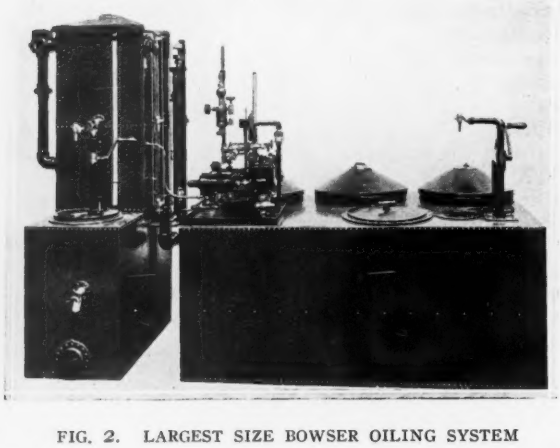


FIG. 2. LARGEST SIZE BOWSER OILING SYSTEM

an hour for each section. The drip tanks have an approximate capacity of 5 times the nominal filtering capacity.

The 3-F type filteration and oiling system is a straight gravity drip return and gravity supply system. This is somewhat similar to other gravity systems. Its chief features being a large filtering capacity, considerable head pressure and little filtering to do because a large separator which removes the heavier impurities before the oil reaches the filter.

The drip and gravity tanks are each fitted with float gages which show approximately the quantities in the tanks. The separator is fitted with 2 glass gages; one shows the water line and the other shows the pressure head of the oil to the filter and likewise its cleanliness.

The oil returning from the engine to the drip tank first enters the large separator which removes the

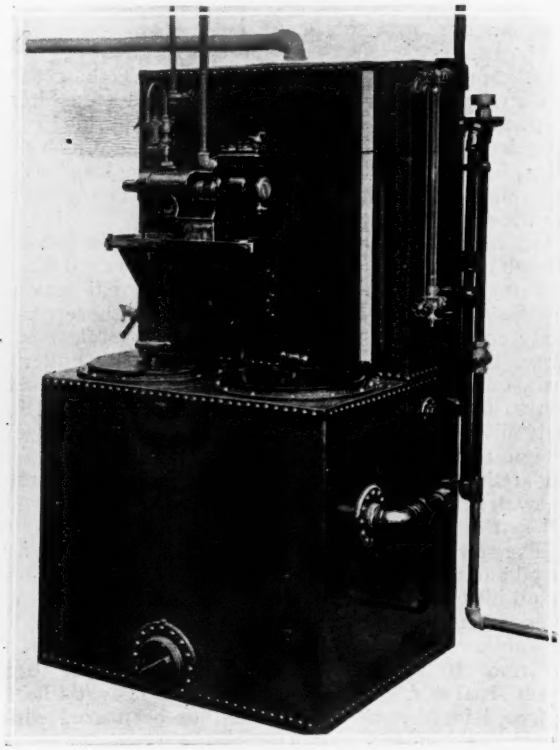


FIG. 3. TYPE 3-F BOWSER FILTRATION AND OILING SYSTEM

heavier impurities. The oil then passes down the stand pipe to the filters. It is then pumped up into the gravity tank which supplies the oil mains.

This system is especially adapted for plants that are shut down occasionally so that opportunity at such times will be afforded for cleaning the tanks.

THE ANDERSON ENGINE ROOM OIL FILTER

WHERE oiling systems are employed, it is frequently advisable to operate the filter under pressure. A filter designed for this purpose is shown herewith. The apparatus consists of a combined stand and drip pan on which is mounted the filter base. This base is fitted with an oil tight cover and a heavy cast-iron center post extending up through a series of spacing rings and corrugated filter plates. Between the rings and filter plates is secured the filtering medium consisting of filter papers and filter cloths. The filter is built entirely of cast-iron, steel and brass and so constructed as to combine a maximum amount of filtering area in the smallest space. It can be operated continuously by either compressed air, city water pressure or direct pump pressure.

THE CROSS OIL FILTER STYLE B

WATER becomes mixed with the waste lubricating oil in many power plants, and considerable difficulty is often experienced in filtering this mixture. The Cross oil filter, style B, which has been developed by the Burt Mfg. Co., was designed for use in such plants. This filter will also take the condensed water and oil from oil separators and exhaust heads and successfully separate the oil from the water and filter the oil so that it will make a good lubricant for pumps and other machinery, the manufacturer however, does not recommend its re-use for engine cylinders.

THE ANDERSON ENGINE ROOM OIL FILTER

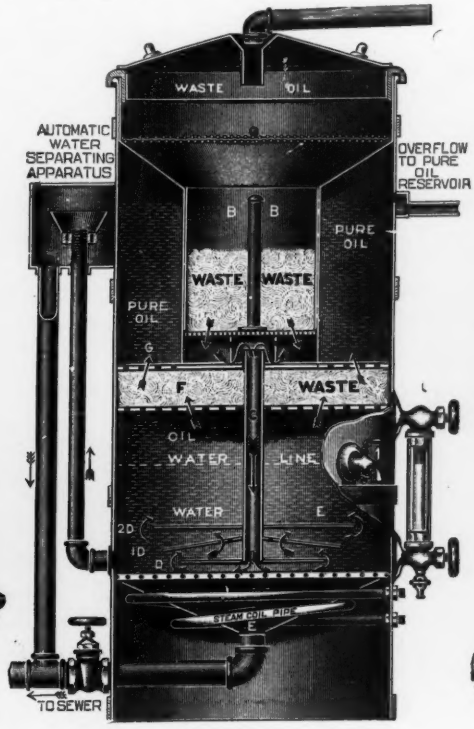


FIG. 1. THE CROSS OIL FILTER

In operation the oil drippings are led to the waste oil chamber in the upper part of the filter and follow the course outlined by the arrows in Fig. 1, the pure filtered oil being delivered through the overflow pipe shown at the right. During its course through the filter the oil is passed through 2 filter beds and a body of warm water which removes all sediment and impurities liable to be found in used oil.

If the waste oil contains water it is automatically separated by passing down tube C, when it reaches the bottom, the oil being lighter than water, immediately rises, and the surplus water passes into the tube which leads to the automatic water separating device shown to the left. The steam coil shown at the bottom of the filter is used to keep the filtering water warm which enables the globules of oil to be more finely divided.

Another type known as the American oil filter, made by the Burt Mfg. Co., is particularly adapted for use in gas engine plants where the hot cooling water is used for heating the waste oil and facilitating its rapid filtration. Pipe connections can be made so that a continuous flow of hot water can be had through the hot water chamber. In this case the oil is passed through 2 screens which enclose animal bone black, during which process the oil is kept warm by the circulation of the water from the cylinders of the engine. The oil is then passed through a bath of water where the remaining sediment may settle out.

CHESTERTON'S OIL FILTERER

OIL to be purified by Chesterton's oil filterer is first passed through a strainer, then a cotton waste or other filtering material, sawdust or charcoal, and finally

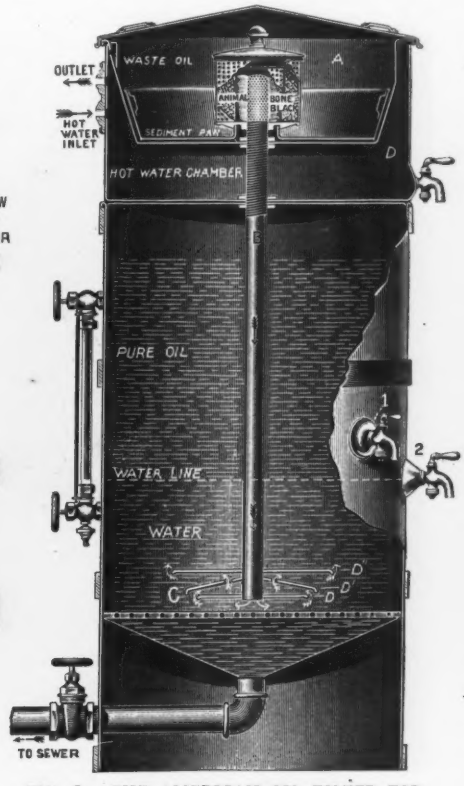
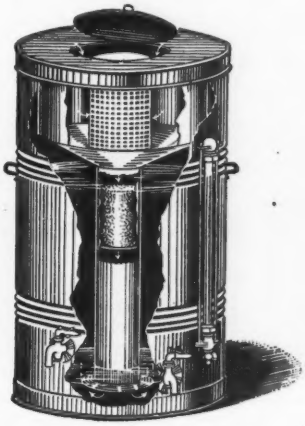


FIG. 2. THE AMERICAN OIL FILTER FOR GAS OR GASOLINE ENGINES

through water. When the oil has risen to the surface and the sediment settled out it is ready for use. This



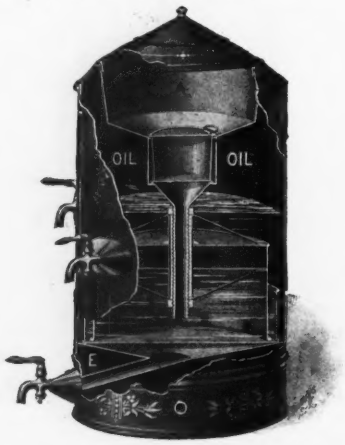
CHESTERTON'S OIL FILTER

filter is designed principally for use in small plants where an oiling system is not employed.

THE ACME OIL FILTER

PURE animal boneblack is the filtering medium employed in the Acme oil filter, which is made by Walter L. Flower Co. This is the medium used in the purification of lubricating oils at the refineries and its use in filters is thus a continuation of the refining process.

Oil to be filtered is not hurried through the process since the force employed is only the gravity of the oil and buoyant effect of water. These forces cause the oil to pass through a screen to the bottom chamber where it is given a bath as it passes up through the water, discharging as it rises the heavier particles of



SECTIONAL VIEW OF THE ACME OIL FILTER

impurities which have been held in suspension. Upon passing up through the boneblack filter bed the remaining impurities are held back and the pure oil rises to the surface whence it is drawn off as needed for use.

The filter is made of heavy galvanized iron and provided with a drain through which sediment and the water gathered from the oil may be discharged. A gage glass indicates to the engineer the amount of water in the filter and give warning when it should be drained.

FRANKLIN OIL FILTER

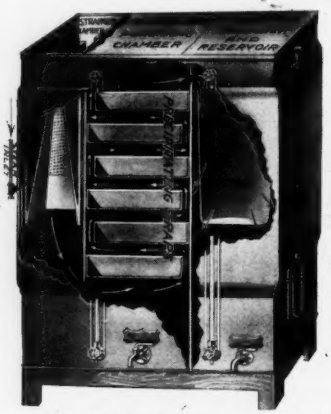
SOME years ago the Franklin Oil Filter Co., who were then manufacturing a filter constructed on the water, waste and steam coil principle (the only principle at that time in use and the only way it was thought oil could be filtered), started experimenting to overcome complaints received from time to time regarding this method of filtration. If the filtering material was not packed tight enough the oil would flow through it freely and come out in practically the same condition as when submitted. The fine particles found in all filtering material would wash through the oil and find their way to the bearings and clog them up. If packed too tightly the filtering material would not allow the oil to flow through and the filter would have to be dismanteled and repacked.

Thinking engineers proved that the water-washing did nothing towards purifying the oil and in fact caused harm, because, unless the oil was of a high grade it would emulsify with the water, form a yellow sulphurous mixture which would not do lubrication and had to be thrown away. On top of this water the heavier particles of oil-soaked grit, lighter than water but heavier than oil would form a floating layer and every drop of oil must work its way through this mass. If perfectly clean oil was poured into the filter it would gather some of this accumulated dirt in its travel upwards.

In the present model, which adheres strictly to the dry process of filtration, that is without the use of water, and the trouble caused by filtering material has been overcome by not using any because no matter if waste, excelsior, boneblack or charcoal was used, the trouble would always occur.

Cleaning, while one of the most important objections, was the easiest overcome, in the present model, there is nothing to be unscrewed, the filter does not have to be put out of commission, the clean oil chamber does not have to be disturbed in any way and the entire operation of cleaning the filter can be done in a few minutes. Every part of the Franklin new model can be lifted out separately and cleaned with a hose or hot water. The majority of the impurities settle in the pans which can be lifted out at regular intervals and cleaned.

The Model A, cut of which is shown, is entirely a self-contained oil filter, arranged to be used singly for hand oiling or system or any number can be connected up in units as increased capacity is desired. The dirty oil is poured or passed into the removable strainer, the oil then passes downward depositing the water and heavier impurities on the bottom, then travels underneath the deflecting wall and must flow horizontally back and forth over the precipitating traps until it reaches the overflow into the filter bag which removes



THE FRANKLIN OIL FILTER

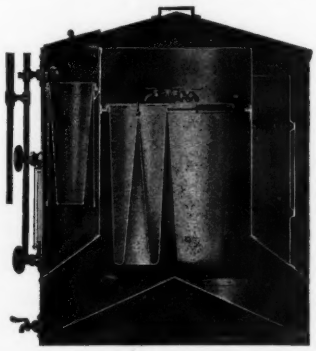
the lighter impurities, and finally enters the clean oil reservoir to be drawn off as needed.

The coarser and heavier impurities being caught on the removable straining surface will fall to the bottom of the strainer out of the way of the incoming oil. As the oil passes downward through the straining chamber it is gradually thinned up relieving itself of the water and entrained substance, and in its flow back and forth over the precipitating traps, which is necessary in order to reach the filter bags, the oil becomes gradually pure liquid by depositing its fine impurities in these traps, and upon reaching the filter bag the impurities are so thoroughly eliminated that the filter bag becomes only slightly discolored after a month of use.

The steam jacket entirely surrounds this filter half way up from the bottom, and applies the heat all around preventing radiation from the bottom up and leaving the oil in the bottom of the filter in a dead calm state, and the impurities settle in the bottom of the filter and the traps will not be dislodged or disturbed by heat circulation.

THE LIBERTY OIL PURIFIER

ONE of the first essentials of an oiling system is some means for purifying the oil which has passed through the bearings, and the Liberty oil purifier, made by the Elliott Company has been designed particularly for this work. The dirty oil being collected through the piping system enters the purifier through a pipe shown at the left of the accompanying sectional view,



VERTICAL CROSS SECTION OF THE LIBERTY OIL PURIFIER

and is discharged into the water settling chamber after having been strained through 2 suspended strainers within the cylinder.

In the separating chamber the oil and water separate, the oil rising to the top and the water settling to the bottom, where it is automatically discharged through the discharge trap shown at the right. This trap permits only a few inches of water to remain in the bottom of the separating chamber and after the separation takes place the oil passes around the purifier again in the opposite direction till it reaches the pipe which conducts it into the filter bag where it is filtered and discharged into the clean oil chamber and passes to the suction of the pump through a pipe near the surface of the oil.

The purifying process is such that all oil is first strained, then separated from the entrained water, after which it is heated to a temperature of about 180 deg., by a steam coil, after which at this temperature, it is passed into the treating chamber where it releases the heavier impurities, thus preventing their passing through the filter bags and clogging them up. The oil is then passed through the bags and is delivered to the clean oil chamber in a pure condition, ready for use.

OIL AND WASTE SAVING MACHINES

FOR reclaiming the oil and saving the waste which has been used in wiping up oil, the machine shown in Fig. 1 has proved very successful. This is a steam turbine driven combination oil extracting and washing machine, which not only saves all of the oil that is gathered up in the wiping material, but is so constructed that the wiping material, after the oil is extracted is put through a washing process and steam dried all in the same machine. The waste after being exposed to the air or other drying process is then ready to be put back into commission.

The first operation is the extraction of oil and grease, and this is done by placing the dirty waste in the basket B, which is revolved at a high speed for a few minutes by means of a steam turbine wheel. The oil is thrown out and drained from the machine through the valve V. The second operation is the washing of the waste and wiping material. This follows directly after extracting the oil and grease, by turning water into the basket, after which the basket is revolved and the water heated by means of a steam jet. When this process has been carried on for a few minutes, the water is drained from the machine and the basket allowed to revolve at full speed for 2 or 3 minutes so as to extract all the water remaining

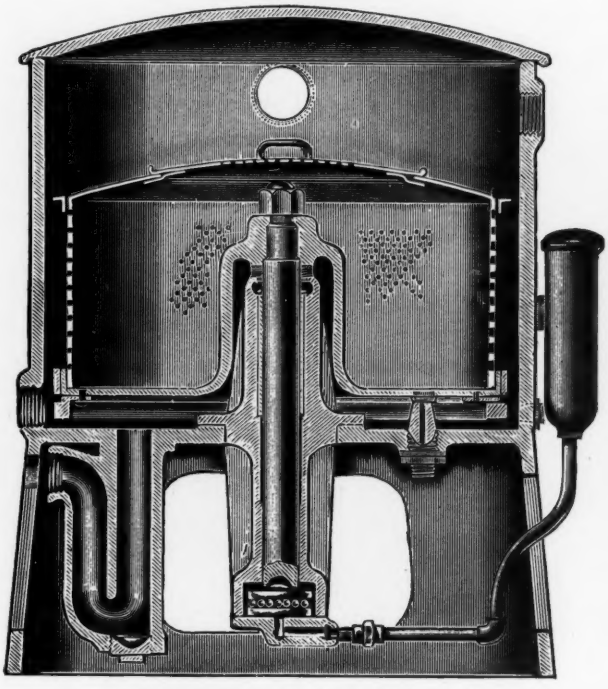


FIG. 1. TURBINE DRIVEN OIL AND WASHING MACHINE

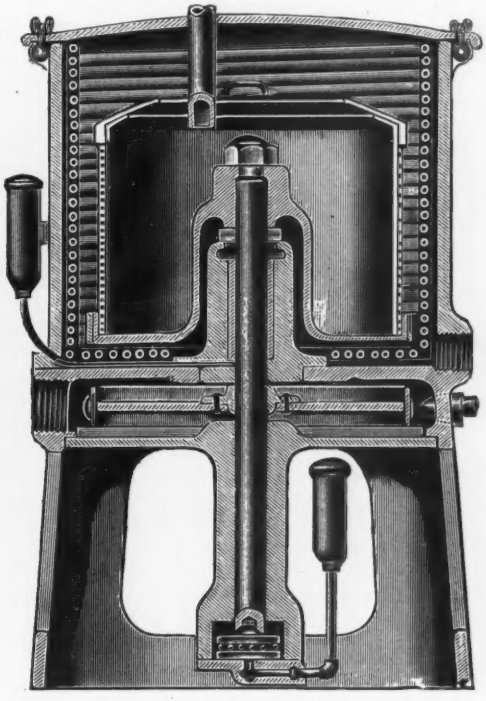


FIG. 2. CENTRIFUGAL EMULSION MACHINE

in the material. The steam supply valve M, to the turbine is then turned off, and the wiping material is placed on dry racks.

In Fig. 2, is shown a steam turbine driven centrifugal emulsion machine which filters the oil by passing it through material mediums of sawdust, cloth and paper, by means of centrifugal force and then drying out all moisture by passing the oil over steam coils.

The top connections for the evaporating coils are piped with direct steam. In this supply pipe is placed a valve to regulate the steam pressure in the coil as temperature necessary for the evaporation is obtained by the pressure of steam in the coils.

The exhaust or drain connection of the coils is to carry away the condensation that takes place in the coil. In this drain is placed a valve so as to maintain a pressure of steam in the coil.

A dirty oil reservoir or supply tank is arranged above the machine and so piped as to deliver a continuous stream of oil to the machine. In the oil supply pipe is placed a valve for regulating the flow of oil. The pipe is so arranged that it may be swung free of the top of the machine to allow the removal of the basket. In the bottom of the supply tank is placed a valve for drawing off any free water that may collect.

In the 3 holes in the top of the machine is placed 3 nipples connected to a common supply with funnel as indicated. The oil supply pipe is arranged so that the oil flowing into the funnel can be seen at all times by the operator.

For the average engine oil, the paper and mat cloth filter is used. The basket is lined with the paper so that the bottom edge curves around the bottom of the basket to a width of about one-half an inch and the top edge extending above the edge of the basket. The paper is overlapped so that the end next to the basket is pointing in the same direction as that of the rotation of the basket. The mat cloth is placed in position in like manner. With the cover on, the paper and mat cloth are pressed tight up against the cover and top of basket.

For very dirty oils or heavy oils, besides the mat cloth, a fine pine sawdust or shavings may be used. Fill the basket loosely with the material and allow the centrifugal force to wall it up to a thickness of about ½ in.

WHITE STAR OIL FILTER APPARATUS

ALL types of White Star filters made by the Pittsburg Gage & Supply Co., operate on practically the same principle. The oil enters a separating chamber and passes through a column of water and collects at the surface, due to the difference in specific gravity of oil and water, then through a filter valve into the filtering cylinders wrapped with specially prepared cloth, and after passing through this cloth it enters the pure oil storage space, ready to be used again.

On the filters for continuous systems an automatic overflow attachment is provided in the separating compartment, which removes the excess water which has returned with the dirty oil, and openings are also provided for connecting the pure oil storage with a pump or pumps, and the drain connections to a sewer or other suitable place for discharging the contents when flushing out the filter.

The essential parts of the continuous oiling system are a filter; storage reservoir, which is so constructed that when the oil reaches a determined level it operates a special float valve and the opening into the reservoir is closed, the oil returning to the filter under pump pressure, whereas, if only an opening was provided to remove the excess oil by gravity above, it would not flow out as fast as forced in by the pump, and the reservoir would overflow, causing a waste of oil; a pump for pumping pure oil from the filter to the storage reservoir and the necessary piping to connect the above equipment to the machinery to be lubricated.

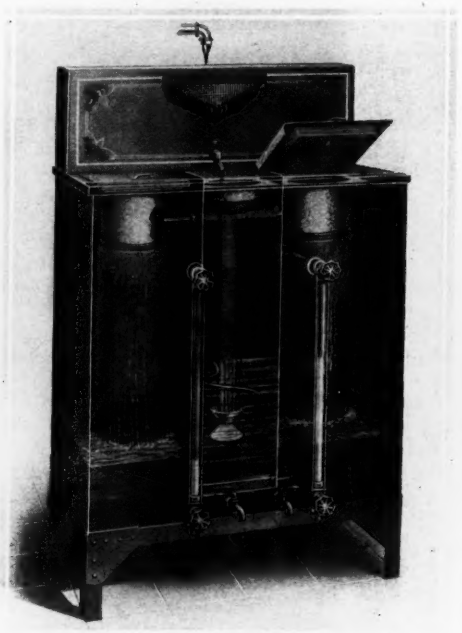


FIG. 1. DUPLEX TYPE WHITE STAR FILTER

If the system cannot be installed so that the dirty oil will drain direct to the filter, some provision must be made to catch the oil, and an individual pump required to pump the dirty oil to the filter.

The round type of White Star filter is used principally where hand oilling is in vogue. These filters

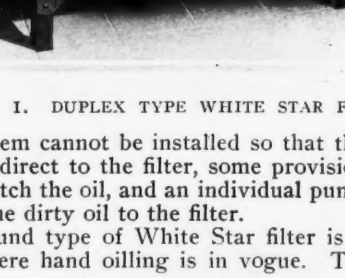


FIG. 2. WHITE STAR OIL STORAGE RESERVOIR

are made in 7 sizes, in capacities ranging from 10 to 100 gal. in 24 hr. In operating this type of filter the oil is collected in pans and emptied by the attendant into the filter and after being filtered, is drawn off to be used again.

The Duplex type of filter which is shown in Fig. 1, is designed for the smaller capacity systems where from 100 to 200 gal. of oil are used in 24 hr. In this type the separating compartment is an integral part of the filter with a filtering compartment on either side and the construction is such as to permit one of the filtering compartments being cut out for the purpose of cleaning the filtering medium.

For capacities of 350 gal. in 24 hr. and upward, the Multiplex type is used. In this type the separating compartment is a unit by itself, and is connected to 1 or 2 filtering compartments, depending on the capacity also governs the number of filtering cylinders or baskets necessary in the filtering compartments.

Among the other apparatus used in connection with White Star oiling systems are the Gaco sight feeds

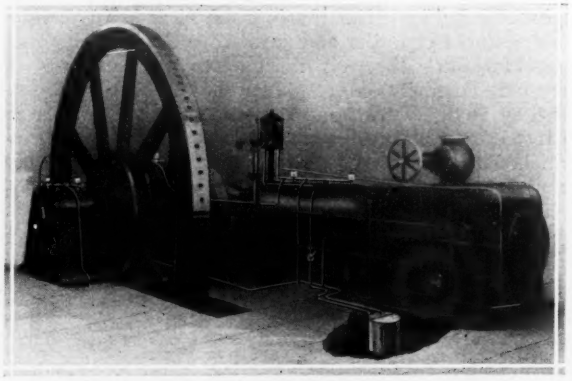


FIG. 3. WHITE STAR INDIVIDUAL CONTINUOUS OILING SYSTEM

for connecting the pipe to the points to be lubricated, drip pans for collecting the dirty oil on engines, etc., in which no provision is made for collecting all the used oil at a central point. Drain tanks to be used in collecting the oil preparatory to being pumped to the filter; auxiliary separating tanks for removing the water from oil containing large quantities of entrained water, and emulsifiers which are special heating devices for aiding the separation of water from emulsified oil.

The essential parts of the White Star individual continuous oiling system are an oil filter, automatic drain tank, a pump for circulating the oil through the system, and the necessary sight feeds, tubing and compression fittings. The filter employed in this system is similar in its operation to those described above, being supported by a 4 ft. pipe pedestal on any convenient point on the engine frame, the filter itself is of the round type and contains but one filtering basket.

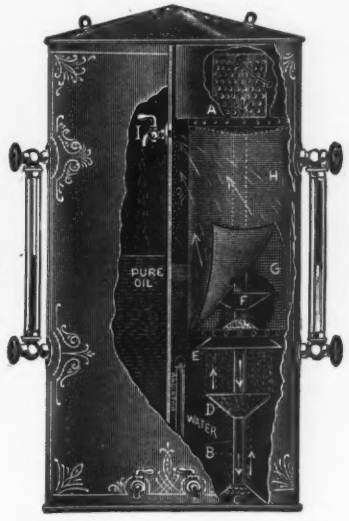
After the oil has passed through the bearings it flows by gravity to the automatic drain tank. This is shown in Fig. 3. Where the foreign matter and entrained water are removed. This tank has an automatic overflow for removing the accumulations of water and can be placed on or below the engine room floor with the necessary drain, and return connections leading to it. As fast as the oil rises to the top of the tank it is pumped directly to the filter.

THE SIMS OIL FILTER

THE interior structure of the filtering section of the Sims oil filter consists of a tank A, to which is connected a tube having attached to it certain cone deflectors. Connected to the bottom of tank A, is a coarse mesh wire screen cylinder G. This cylinder is covered with suitable filtering material H, through which the oil must pass on its way to the clean oil section. Inside of tank A, in the smaller sizes, is placed a perforated bucket into which the dirty oil is poured. The medium size filters are provided with a receiving tank, the same as the large or duplex type, but the duplex type is provided with an automatic overflow when used on continuous oiling systems.

To operate the filter, fill the filtering section up to the point indicated in the illustration; pour the oil to be filtered into the bucket which will remove the coarse impurities. The oil will then descend through the tube as indicated by an arrow. Having reached the cone C, it will ascend through the perforations and gather on cone D; leaving this it will gather on the inside of cone E, the diameter of this being greater than D; leaving this section through the perforations it gathers on cone F, and ascends into the body of oil floating on the surface of the water. These cones distribute the oil in a thin film over a large surface as it passes upward through the water, giving a better opportunity for washing.

Having reached the inner portions of cylinder G, the oil passes through the filtering cloth H. The



THE SIMS STYLE A OIL FILTER

advantage claimed for this upward filtration is that a large area of filtering surface is obtained which is represented by the entire area of the cloth from the surface of the water to faucet I. The effect of this large filtering area is the slow movement of the oil being filtered.

THE ECLIPSE ROUND TYPE FILTER

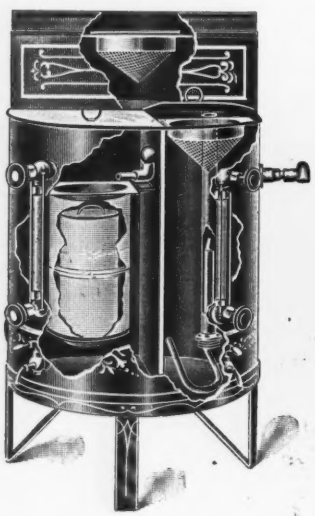
IN the Eclipse filter, made by the Standard Gauge Mfg. Co., several distinct operations take place. The dirty oil enters the filter through a screen which removes the coarser matter and then passes through a pipe terminating under water in a system of screens and baffles by which the oil is divided into particles, the heavier impurities falling to the bottom of the chamber, the finer divided oil being released at the bottom of the reservoir of hot water rises to the top, owing to the difference in specific gravity. During this passage through the hot water the oil is heated, its density being much decreased in which condition the washing is thorough. The oil collects on top of this

water bath and runs off automatically to the filter chamber, the walls of which are made of cloth through which the oil passes, thus removing all remaining particles of foreign matter that may have gone through the other operation.

This filter was developed for smaller plants in which continuous oiling systems are not in use, the dirty oil being delivered to the filter by hand. The flow of the oil to the filter is automatically controlled by a valve which prevents flooding and renders the process uniform.

TURNER OIL FILTERS

IN the Turner oil filter the general plan of filtration hastens the slow action of gravity and aids the natural tendency of the dirt to precipitate, producing clean oil in a short time of filtration. The filter beds are composed of long fibre excelsior whose numerous



ECLIPSE ROUND TYPE OIL FILTER

sharp edges serve to break up the oil into small particles. In the last filter bed is a layer of hair felt. The excelsior does not pack down, mat, or become clogged up, therefore frequent renewals are unnecessary, and when the time does come for replacement it can be accomplished at small expense and in a short time.

The filter shown in Fig. 1 is for mills, factories and power plants. The heated oil spreads out under a perforated plate, forming the bottom of the filtering bed (partly submerged in warm water). The oil rises uniformly through the filtering material and water to the cone whence it passes through the perforation as indicated by the arrows, into the dirt chamber H, under another perforated plate. It now circulates through another filter bed, passing out of section A at the opening L, into the vertical pipe leading to the bottom of section B.

Here occurs a repetition of the process described for section A, the oil leaving the chamber at M, through a pipe on the other side of the filter case, entering the clean oil reservoir C, through valves P, P′, and strainer cylinder N.

In Fig. 2, is shown the cross sectional view of one of the Turner filters designed particularly for steam turbine plants. The oil, hot from the bearings, enters through the inlet pipe A, discharging below a perforated plate and rises through the filter bed and trays, to the upper chamber and passes out through the opening L, leading through this pipe to the bottom of the second chamber. Here the process is repeated until the oil passes into the next compartment. This compartment is the cooling chamber, cooling being accomplished by means of a cold water coil with inlet and outlet R and S, respectively.

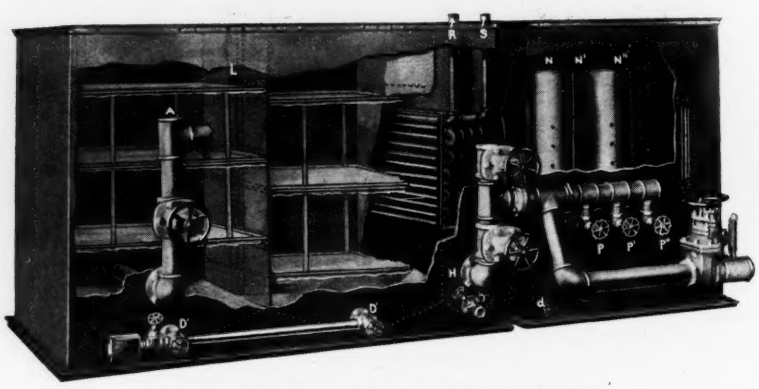


FIG. 2. INTERNAL VIEW OF TURBINE FILTER

From the cooling chamber the oil passes out at H, and thence through the piping to the valves P, P′ and P″, controlling the entrance to the clean oil chamber through the strainer cylinders. The oil can be fed into either one, any 2, or all 3 strainer cylinders N, N′, and N″, being carried to the top of the cylinder through vertical pipes. The mouths of these pipes being higher than the top of the cooling coil in the preceding chamber insures a constant level of oil at the top of the coil, which is thus kept entirely submerged.

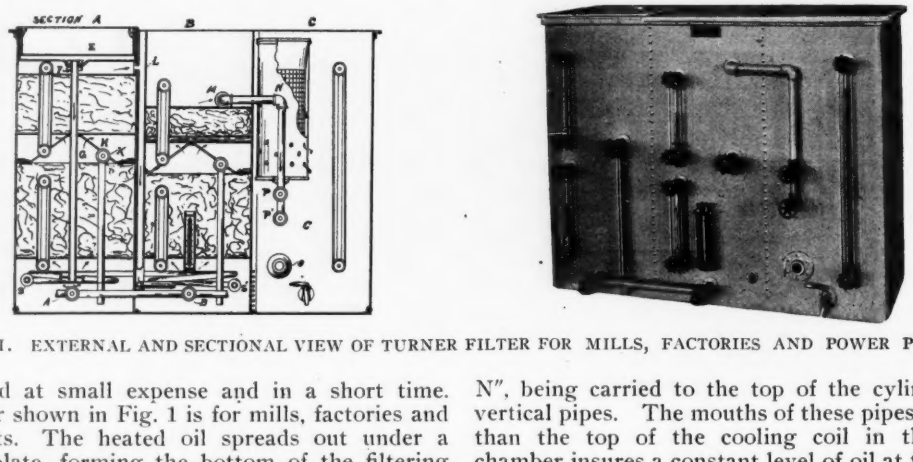


FIG. 1. EXTERNAL AND SECTIONAL VIEW OF TURNER FILTER FOR MILLS, FACTORIES AND POWER PLANTS

THE WHY, THE WHAT AND THE HOW OF LUBRICATION

By James A. McDevitt*

HAVING been asked to discuss this very important subject, we shall begin at the beginning and ask "Why is lubrication necessary?" and then answer it without any technical terms or theoretical deductions.

Any engine, or machinery of any kind, when in motion, will have 2 metal surfaces rubbing together. If this were to continue for a length of time, which of course would be longer or shorter, according to the character of the bearing, the speed at which it is running, and the nature of the work, the rubbing surfaces would become dry and then heat up. The friction would become greater and greater as the heat and the dryness increased, and finally would come the moment when the babbitt metal melts from the box, or if a hard metal bearing the 2 metals cut into each other and become as firmly wedged as though welded together. In the latter case it has often meant the complete wrecking of an engine or machine, as the case might be.

But, even without taking for example the wrecking of machinery, the extra load put on bearings through excessive friction is reason enough why lubrication is necessary. When a bearing gets dry, or partially dry, the increased friction which results means of course more power to turn or move that particular object. So that it can be readily seen that where there are a number of such places not properly lubricated the extra power required to overcome such excessive friction is sometimes enormous.

Now after being convinced of the necessity of lubrication, we come to the second part of our subject, "What is lubrication?"

Lubrication is the process of getting a material in between the closely fitted bearings of machinery, so that the metal surfaces of the 2 bearings be kept apart, and thus reduce friction to a minimum.

The best lubricant then, is that which has the greatest adhesion to metallic surfaces, and the least cohesion in its own particles.

The materials used at the present time for this purpose are oil and grease, and a discussion of the merits of these lubricants brings us to the third part of our subject, "How to lubricate."

Lubricating oils may be divided into 2 general classes, petroleum or mineral product and animal oil, which is rendered from the fat of animals.

Grease, that is the best grades, are a composition of both animal and mineral oils.

Then again, there is a class of oils which we will call vegetable oils, but they are very little used for lubricating purposes. It will be well, however, to enumerate a few of them for general information. They are, castor oil, cotton seed oil, olive oil, linseed oil, gingelly, ground-nut, colza, etc.

Each of the 2 general classes mentioned above may again be subdivided into a great many classes, each of which has its particular adaptability for some special work.

For instance, in the animal oils, Neatsfoot can be classed in a half dozen different grades, ranging from best to poorest quality. The same can be said of lard oil renderings.

In mineral oil, we have as a starter crude oil, which is the product as it comes from the ground. It is then distilled and the various mineral brands are taken in turn from this distillation.

Benzine is the first product off, then comes gasoline and naphtha; then come the illuminating oils, and next the machine and engine oils. Finally, after all the lighter oils have been distilled, what is left is the cylinder stock.

As the name indicates, this is the product that is used for lubricating the cylinders of steam engines. It possesses a very high fire test, ranging from 550 to 700 deg., and the viscosity increases with the fire test. While the straight cylinder stock can be used, a compound of cylinder stock and 20 cold test Neatsfoot oil make the best cylinder oil obtainable. The Neatsfoot causes the mixture to cling to the walls of the cylinder and thereby produces more complete lubrication.

As has been said of the animal oils, the same may be said of the mineral oils, all depending upon the locality from which the crude oil came. Pennsylvania crude is generally conceded to be the very best.

As to what grade of cylinder oil to use is largely a matter of judgment with the user. What must be considered is the fire test, the viscosity, and in the case of gas engine oils, freedom from carbon.

Absence of carbon is of no especial benefit to steam engine cylinders, as the temperature of these rarely go above 400 deg., which is not sufficient to burn even a fair cylinder oil.

On the other hand, the temperature of gas engine cylinders goes as high as 2000 deg., and it is absolutely necessary to use a stock which has been filtered and thereby loses its carbon. If the carbon is not filtered from oil for gas engine use, the excessive heat burns the oil and leaves the carbon as a deposit, which will soon give all kinds of trouble to the engineer.

Therefore, never use a dark oil for gas engines, as the darkness indicates the carbon in it. The oil should be filtered, and while this reduces the fire test, yet a lowering of the fire test with an absence of carbon is much better than the reverse.

As to the proper lubrication of machinery bearings, it has always been thought that the most fluid oil, consistent with the work to be performed, and the speed of the machine was good practice. That meant practically that on light, fast running machinery, a light fluid oil was best, and for heavy, slow moving bearings, a heavy body, viscous oil that would adhere closely to the journal and not run off, was the most desirable.

Now, in machinery oil, one thing to be guarded against is the amount of solid matter left in the oil during the process of manufacture. In mineral oil, this is a paraffine wax and in animal oil stearine. This solid matter possesses absolutely no lubricating value, and must be extracted to produce the highest grade.

The manufacturer of petroleum extracts the wax by a settling process, or by pressure. The manufacturer of animal oil must extract the stearine through a chilling process, which explains why Neatsfoot oil is always rated by its cold test properties.

This process is done by freezing the tender oil and pressing it through canvas at an enormous pressure, thus separating all the stearine or solid matter from the virgin oil.

It has always been agreed among well posted oil

*Chief Engineer F. S. Walton Co.

manufacturers, experts and dealers, that a pure Neatsfoot oil, of an extremely low cold test, is the very best lubricant obtainable. But its high price has prevented its general use.

True oil is necessarily a liquid, and waste occurs from the fact that it is a liquid and drips or flies from a bearing.

After an experience of 25 years in the oil business, we came to the conclusion that in order to obtain as nearly perfect lubrication as possible without waste, it would be necessary to convey the oil to the bearing in a solidified form, as well in the smallest consistent quantity. In other words, we found from experience that lubricants commonly called greases are more economical than fluid oils.

Fully appreciating the extraordinary lubricating qualities of a low cold test Neatsfoot oil, and understanding equally as well the advantage possessed by a high grade mineral oil, free from wax, the logical conclusion was that a proper combination of such oils, so treated as to form a lubricant of solid form instead of fluid, would prove far superior to the ordinary lubricating grease, and prove the most satisfactory lubricant.

After having perfected our grease, which we market under the name of Zorozo, we are only too glad to publish some actual tests which have been made under our direct supervision.

On a 25 hp. Sturtevant double eccentric engine, 175 r. p. m., the following was the result of a one week's test, 24 hours per day, 7 days per week:

	Zorozo No. ounces consumed
Crank pin	3
Main bearing	3
Out bearing	3
Eccentrics	2
Cross-head	1
	12

By multiplying by the number of weeks in a year and dividing by the number of ounces in a pound and then dividing by the horsepower of the engine, the cost of lubrication per horsepower per year is easily determined. $12 \times 52 = 624$ oz. $624 \div 16 = 39$ lb. per yr. $39 \div 25 = 1\frac{1}{2}$ lb. per hp. per yr.

Another practical test that we gave was on a Goulds triplex power pump, pumping ammonia for a Carbondale Absorption System refrigerating machine. This pump also runs 24 hr. a day, 7 days a week, and was equipped with seven 1½-oz. oil cups. These oil cups were filled every day with the best grade of engine oil.

On the 7th of last February they were replaced with one ounce grease cups, which were filled with Zorozo. They were not refilled until June 8, and the pump was working every minute of the time. This may seem startling to most engineers, but it's true.

To Find the Temperature at Which the Oil Congeals

PUT 15 parts of Glauber salts into a beaker. Place in this a bottle containing a sample of the oil. Place over the salt a mixture of 5 parts hydrochloric acid and 5 parts of cold water. The temperature is reduced slowly, and can be observed from time to time as the oil thickens. Any freezing mixture or even ice can be used in place of the above.—R. P. Clarkson, in Scientific American.

LUBRICATION OF AIR COMPRESSORS

By G. W. M. Boycott

EXPLOSIONS or ignition of gases are common in receivers and discharge mains, and sometimes occur in the compression cylinder itself.

An ignition may take place without wrecking the receiver or main, but a large quantity of smoke and flame will be produced. This is extremely dangerous in the case of large tunnel works or caisson making, when the workers are actually breathing the compressed air. In this class of work, therefore, an ignition is as much to be feared as an explosion. Those who may never have seen a receiver on fire will hardly be able to appreciate the quantity of flame and smoke produced, which is very large.

Combustible gases are evolved from lubricating oils, when a certain temperature known as the "flash point" is reached. At a somewhat higher temperature, called the burning point, the vapor will ignite, and, if mixed with the right quantity of air, explode.

The percentage of combustible gas to air is usually small—in the case of hydrogen 8 per cent.—and decreases with the temperature. Mixtures nonexplosive at low temperatures become explosive at high. Low flash oils have a flash point of about 250 deg. F. High flash cylinder oils have a flash point of about 400 deg. F. But for air compressors, these average flash points are not high enough, and special heavy oils having a flash point of at least 500 deg. F. should be used. Such oils will have an ignition point of about 600 deg. F. It will be seen, therefore, that we must never allow the terminal temperature of compression to rise above 600 deg. F. Compression in a cylinder is of 2 kinds—isothermal and adiabatic. These words are derived from the Greek, and the first means, literally, "equal temperature," and the second, "unable to pass." Isothermal compression, therefore, indicates that the temperature remains constant during compression. This can only happen when the heat produced by the work done upon the air in compressing it is got rid of by cooling the air.

When compression is adiabatic the air retains all the heat produced, and does not part with any of it. In actual practice compression cannot be perfectly either isothermal or adiabatic. By water jacketing the air is cooled as much as possible, but the cooling area is so small in comparison with the volume of air compressed, and the time so short, that we should be more nearly correct in treating compression as adiabatic than as isothermal; and in considering the question of lubrication we are keeping on the safe side in doing so.

We will take a case of compression by single-stage, compression up to 45 lb. by gage, which is one we often meet with in caisson or tunnel work. Making use of the formula

$T = R^{29} T$, in which

T = absolute temperature of compression.

R = the isothermal ratio of compression.

T = the absolute temperature of free air.

We shall then get the results shown in Table 1, in the second column for the temperature after compression.

This table shows very clearly the need of a high flash point cylinder oil. We must remember that al-

though the free air supply may have a comparatively low temperature, yet that the air drawn into the cylinder gets heated by coming in contact with the heated metal, and that, therefore, the initial temperature may sometimes be quite high.

A leaking discharge valve may cause an appreciable rise in the initial temperature, and when this occurs it is not difficult to understand how, in a few strokes, a dangerous temperature may be reached. As an actual matter of fact, oil having a flash point of 412 deg. F. has been found to vaporise when compressing up to 38 lb. A remedy was found by using oil with flash point of 700 deg. F.

A possible objection that may be made to these heavy oils is the deposit of carbon; but if care be taken to use only the minimum quantity of lubricant required, this will not occur.

Although about 45 lb. is the maximum pressure required for pumping into the tunnel at the maximum depths at which these are usually driven, yet air at a pressure of at least 100 lb. will be required for working rock drills and other pneumatic tools. Such compression may be either 1 or 2 stage. The latter is

TABLE I. TEMPERATURES, DEGREES F. BEFORE AND AFTER ADIABATIC COMPRESSION

1	2	3
BEFORE COMPRESSION	COMPRESSION TO 45 LB.	COMPRESSION TO 100 LB.
60	317	479
100	377	532
140	437	624
180	497	697
220	557	769
260	617	841
300	676	911

safer and more efficient, but if one stage is used the temperature will be according to column 3.

With 2 stage compression the terminal compression may be kept down by means of intercooling. Thus, suppose the air be compressed in the low-pressure cylinder up to 25 lb. The temperature would then be 231 deg. F. If the air is then passed through an intercooler and cooled to 60 deg. and then compressed in the high-pressure cylinder up to 100 lb., the terminal pressure cannot be greater than 247 deg. It will therefore be seen that 2- stage compression has great advantages from the point of view of lubrication, as not only does it tend to prevent dangerous explosions, but also the carbonising of the lubricant and its deposit on ports and valves.

On no account must the engineer in charge of an air compressor introduce light oil through the inlet pipe for the purpose of cleaning out the valves or extra lubrication. Under such circumstances the conditions for an explosion are ideal, as the oil will be drawn in in the form of spray and atomised, then compressed with air, just as in the case of the ordinary oil engine. Should an extra dose of lubricant be required, the only expedient permissible is to introduce soap and water through the oil pump.

It is a great advantage to take in clean air from outside the compressor rooms. This advantage will be more particularly felt in winter. From the first table it will be seen that a difference of 40 deg. in the initial temperature means a difference of 60 deg. in the final temperature. It is therefore well worth while endeavoring to obtain a supply of cool free air.

TURBINE LUBRICATION

By H. P. Lampert

MUCH has been said and written about lubricants and lubrication of reciprocating engines, but very few articles have been written or printed relative to Turbine Lubrication. This can be attributed to 2 causes:

1st,—The infancy of turbine engine operation in general;

2nd,—The lack of time for experimenting to gain the knowledge required and to distribute to engineers the desired information for the satisfactory and economical lubrication of the horizontal or vertical turbine engine.

Lubrication of turbine engines is vastly different from that of reciprocating engines, and further, there is a difference in the conditions and requirements for the satisfactory and economical lubrication of the horizontal turbine as against the vertical turbine.

In the horizontal turbine the bearings are so proportioned that the entire weight of the rotating or revolving part is supported upon a film of oil through capillary action alone, there being no oil pressure whatsoever, and if properly lubricated, the shaft should never come in contact with the bearings but be separated by the film of oil.

In the vertical turbine conditions are vastly different. There are, in addition to the oil hydraulic governor, 3 bearings, namely, the step-bearing, the middle guide and the top guide, all to be lubricated and under different conditions. The step-bearing is supplied with oil at a pressure sufficient to float or keep in suspension, while revolving at 720 r. p. m., a weight depending upon the size of the unit. For instance, if it be a 14,000-kw. unit, the weight to be suspended would be approximately 120 tons, which would require an oil pressure of about 900 lb. at the step-bearing. The middle and top bearings and the hydraulic governor are supplied with oil at 150 lb. pressure. Also, these 3 bearings must be lubricated with a film of oil, under pressure, between the rotating parts and their bearings.

It has been proved that a pure mineral oil is best adapted for the purpose of turbine lubrication, but there are very few oils on the market that give even fairly satisfactory results. A great many of these oils are not properly treated or compounded, and when passed through the filter emulsify, thereby causing no end of trouble to the operator of the turbine. Also in a great many cases an oil apparently may be doing work and separating properly, but when the turbines are run with an extra load, causing a greater pressure on the film of oil at the step-bearing, suddenly the oil will go to pieces and the turbines be shut down for repairs. This is due to the fact that the oil has not the proper wearing qualities, and when the maximum speed of the turbine has been attained, the oil will be burned and thus lose its viscosity.

The following will no doubt be of great interest to turbine operators. The results were obtained in vertical type turbines, consisting of one 5000-kw. unit and 2 9000-kw. units, the oil used for the lubrication of same being at the rate of 85 times per 24 hr., and the one charge of oil was in commission from November, 1909, until July, 1911. Average temperatures of one

5000 and 2 9000-kw. turbine engines for different periods were as follows:

November, 1909:
Top Bearing .....146 deg. F.
Middle Bearing .....165 deg. F.
Step Bearing .....139 deg. F.

May, 1910:
Top Bearing .....104 deg. F.
Middle Bearing .....131 deg. F.
Step Bearing ..... 95 deg. F.

September, 1910:
Top Bearing .....120 deg. F.
Middle Bearing .....139 deg. F.
Step Bearing .....131 deg. F.

June, 1911:
Top Bearing .....140 deg. F.
Middle Bearing .....183 deg. F.
Step Bearing .....171 deg. F.

The above results were obtained through careful study of conditions and requirements of the turbine engines and similar results can be obtained in any turbine operated plant.

LUBRICATION OF REFRIGERATING MACHINERY

By William M. Davis

IN the lubrication of the ordinary type of refrigerating engines, 3 different kinds of lubricants are required; cylinder oil, for use in the steam cylinders, engine oil, for lubricating the bearings, crank pins and other motion parts; and ammonia oil, as it is usually called, for the lubrication of the piston rods of the ammonia cylinder; and the successful operation of the machinery will depend to a great degree upon the intelligent selection of oils suitable for these various requirements.

Steam Cylinder

IN the lubrication of the valves and pistons of the steam cylinders ,a good grade of cylinder oil is required.

Oil for this purpose has for its base what is known as cylinder stock, to which is usually added a small amount of some fatty or saponifiable oil. Cylinder stocks are of two grades, one, usually of a light green or reddish color, known as filtered stock, and the other, usually of a dark olive green, known as steam refined cylinder stock. As far as lubrication is concerned, there is but small difference between them and their use is largely a matter of choice; some engineers prefer a dark oil, some a light oil.

In the lubricating of steam cylinders of refrigerating machinery, especially where ice is made, certain points must be looked after that are not essential in any other class of engine. In the manufacture of ice, it is usually customary to condense the exhaust steam, purify it by filtration and use it for making ice.

The process is as follows: The exhaust steam first passes through a separator, where the steam is relieved of some of the oil that it may contain; it then passes to the feed-water heater, where it imparts some of its heat to the boiler feed water, then it goes to the condenser and the water of condensation is pumped to a re-boiler and skimmer; any oil that has not been removed in the preceding processes is taken off, the water passes thence to the cooling coils and through bone dust or charcoal filters, and is still further cleansed of its impurities. From there it passes to the settling or sweet water tank, as it is called, and it is finally drawn off to a sponge filter on its way to the freezing cans.

From this it will be seen how important it is that the water be kept as free from oil as possible. If the oil contains any great amount of animal fats in its composition it will form a white, milky emulsion with the water that will be very difficult to remove. For this reason it is customary to use an oil of either pure petroleum or a very small per cent of fatty oil. Some engineers prefer to use an oil without any fatty matter whatever in it, but it has been the experience of the writer that for an engine having large cylinder or heavy valves, better and more economical results can be obtained by using an oil containing a small amount of fatty oil. If the steam in the cylinders is absolutely dry, there is no question but straight petroleum oil would answer very well, but as there is always moisture present, due to condensation in the steam pipe, expansion of steam in the cylinder, etc., as stated above, better results can be obtained by using an oil containing a small amount of some fatty oil.

The writer can recall one instance where he was called to investigate a complaint about trouble with cylinder oil at a large brewery which also manufactured ice. The engine had only been in use a short time and the erecting man who set up the engine had told the engineer that he must use nothing but a straight petroleum oil, otherwise he would have trouble separating the oil from the water. After a while the engineer noted a very decided groan in his engine valves, and no matter how much oil he fed in, he could not get them to run quietly. The writer was sent for, and on going to the plant found that they were using several gallons of oil per day, yet the engine valves groaned very badly. The engine was located several hundred feet from the boilers, the steam pipes were not covered and there was no separator in the steam line, so that the steam carried a good deal of moisture with it.

On noting these conditions, the writer advised that, at least until the pipes could be covered and separator put in the steam line, an oil containing some fatty matter should be used. The engineer protested against this and gave as his reason for objecting, the directions given him by the erecting man. The writer, however, finally obtained permission to make a demonstration to see what could be done to stop the groaning of the valves, and filled the lubricator with an oil containing about 5 per cent of acidless tallow oil.

As stated above, no matter how much of the straight petroleum oil was used, it was impossible to stop the groaning of the valves, but within a half hour after the compounded oil was started, and feeding only one drop per minute, the groaning ceased and the valves worked freely and easily right straight along at that rate of feed, and the amount used was so small that it caused no trouble in the system.

So where the steam is quite dry, it may be advisable to use a straight petroleum oil, but if there is any appreciable amount of moisture in the steam it will be better to use compounded oil; that is, one containing a small amount of acidless tallow or neatsfoot oil; usually 3 to 5 per cent will be sufficient to give good results.

Cut Down the Oil Supply

IT is well, however, for the engineer in charge of the refrigerating plant to go on the theory that the less oil used in the cylinders the less there will be to separate from the condensed water. The steam cylinders of refrigerating machines are not, as a rule,

very large, the piston speed does not usually exceed 400 to 600 ft. a minute, so that, if a good quality of oil is used, very little will be required to give good lubrication. If it is desired to make a test to see how little oil is really necessary, I would advise the following precedure:

Gradually reduce the oil feed, keeping a record of the amounts used, the number of drops per minute, or pints per day, and when an opportunity offers, remove the cylinder head and wipe over the cylinder surfaces with a white paper. If a good stain of oil is found on the paper, it is an indication that enough oil is being used. Then reduce the oil feed and repeat the process until on examination it is found that the oil stain is becoming faint, in which case increase the feed slightly, and make that as the minimum amount or allowance for this engine. To one who follows out this practice, it will often be surprising how little oil is really needed to give good lubrication.

As an instance of what can be done, the writer knows of 2 engines at one plant, each of them having cylinders 24 by 48 and making 100 r. p. m., having a piston speed of 800 ft. a minute; the regular allowance for each of these engines is a pint per 12 hr., or about 7 or 8 gallons a month for both engines. This oil carries 5 per cent of fatty oil and is bought at a very reasonable price. At this rate of feed the valves always wear smooth and free and the cylinders when open always show a good coating of oil.

Colored Ice

PRESENCE of a yellow or reddish color in ice is often attributed to the cylinder oil getting into it. This may sometimes happen when the oil is used too freely, or the filters are out of order; but as a general thing the stain is due to the presence of rust in the water. Condensed water has a very active effect on iron when combined with oxygen, and when the plant is shut down and the pipes are empty the action of the air on the moist pipes soon causes them to rust, and when the plant is started again, unless care is taken to prevent it, the rust will be deposited in the freezing cans.

Continuous Oiling

CONTINUOUS operation of refrigerating engines will depend very greatly on the liberal supply of good oil for the bearings, crank pins and other moving parts. This can best be obtained by use of a continuous oiling system, so arranged by means of tanks and piping, that a copious stream of oil can be kept going at all times over all the bearing surfaces. Oil having passed over the bearings should flow through a good filter to free it of dirt or other impurities that may have got into it, and thence be pumped into an overhead tank to be used over again. If the engine is thus properly equipped and provided with shields, pans, etc., the loss of oil or rather the amount necessary to make up the loss should be very slight.

The writer knows of one particular instance of 3 large refrigerating engines, running night and day, where when the engines were first started the overhead tank was filled with 250 gal. of oil, and at the end of six months the loss of oil had been so small that it had not been thought necessary to put any additional oil into the tank.

At another plant the writer knows of having 2 large Corliss engines equipped with continuous oiling system the oil was run in streams over the bearings, yet so well protected were they that the loss for one year averaged 7½ gal. per month for both engines. An oil to be suitable for this purpose should be straight petroleum product, having a flash test of 350 to 400 deg. F. and viscosity of 150 to 180 seconds at 100 degrees.

Ammonia Cylinder

CONSTRUCTION of most modern ice machines is such that it is necessary that an oil be used to lubricate the piston rods; this is usually done by pumping oil into a space between the stuffing box rings. But no matter how tight the packing is kept, some of the oil will work into the cylinders and pass out with the ammonia gas; notwithstanding the fact that the discharge pipes are provided with separators, some of the oil will pass into the refrigerating system so that it is essential that an oil for this purpose have a low cold test so that it will remain in a fluid state after it reaches the expansion coils.

If the oil should be of too viscid or of too high cold test, it will congeal in the expansion coil and form a coating over their surfaces, thus lowering the efficiency of the refrigerating system.

In the manufacture of artificial ice, or to speak more correctly, in mechanical refrigeration, the anhydrous ammonia gas is compressed in the compression cylinders to about 120 to 200 lb. pressure per sq. in., according to the class of work done, and the requirements of the plant. It is then allowed to expand to about 15 lb. in the expansion coils. In some types of machines the oil is used to lubricate the ammonia cylinders and pistons and to fill the clearance space and to reduce the heat of compression, for, in compressing the ammonia gas to the required pressure, its temperature is raised to about 180 to 200 deg. F. Oil for this purpose must have a flash point so high as to not give off any great amount of vapor.

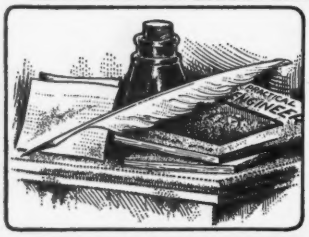
After the ammonia has been compressed to the proper extent, it is allowed to flow through the expansion coils and thus produce the refrigerative effect.

All refrigerating plants are provided with a separator in the ammonia discharge pipe which is supposed to and to a certain extent does separate the oil and other foreign matter from the ammonia; but a certain quantity of oil will always go past the separator in the form of vapor and collect in the condensing coils, so that it is essential that the oil be of such a nature that it will remain in a fluid state when subjected to low temperatures

An oil for this work should be of about 300 to 325 flash test, and stand a temperature of 5 deg. above zero without congealing.

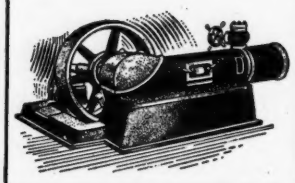
The oil that is recovered from the refrigerating system will often be somewhat more viscid and darker in color than before being used, but it can be used over again on the machinery or put into the oiling system with the engine oil.

COMPARISON BETWEEN the largest passenger locomotives recently built for the Pennsylvania Railroad and the oldest locomotive in America are interesting as showing the progress made since the first railroad train ran on the Camden & Amboy Railroad in 1831. The the John Bull, is still at the Museum in Washington. The weight of the locomotive and tender of the new Pacific type, or K2, as it is called, loaded with coal and water, is about 430,000 lb., while the John Bull loaded for operation weighs 24,625 lb. The new engine has 6 driving wheels, each 80 in. in diameter, while the driving wheels of the old engine are 54 in. For the new locomotive the total heating surface is 4,619.9 sq. ft., while the older one has 213 sq. ft.



Letters from Engineers

Bright Ideas direct from the plant. Send us yours. Cash paid for those accepted. Sketches desirable; we make the drawings

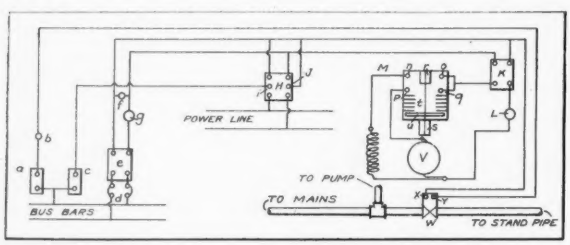


A REMOTE CONTROL PUMPING STATION

ABOUT 3 yrs. ago a remote electrical control system was installed in a city pumping station which has been in successful operation ever since. The original pumping outfit consisted of 2 steam pumps with the necessary boilers and equipment. As this pumping station furnished water for fire protection, as well as for the domestic use of the city, it was necessary for an attendant to be on watch during the 24 hr. of the day.

The steam pumping apparatus was very inefficient and it was getting old, so that it was only a matter of a short time when it would have to be replaced.

About this time it became evident, to the men in charge, that a considerable saving could be made by laying off the steam pumping apparatus, while it was still capable of doing the pumping, and saving it for emergency purposes, and installing an electrical pumping outfit that could be operated and controlled from



ELECTRICAL DIAGRAM FOR REMOTE PUMP CONTROL

the city lighting and power plant, which was located about ¾ mile from the pumping station. With this end in view, a 500-gal. per min. triplex pump, geared to a 40hp. 250-volt d. c. motor, was installed in the pumping station.

The switches, lamp and instruments, a, b, c, d, e, f and g, shown in the sketch, are mounted on the pump panel of the switchboard in the lighting and power station. The switch K, wattmeter L and motor starter M are mounted in the pumping station. W is an electrically operated valve placed in the water main between the pump and the standpipe. H is an electrically operated switch which is mounted on a pole near the pumping station and used to connect the main power circuit in parallel with the pumping circuit.

The switch K is left closed so that the motor V, which is geared to the pump, is started by closing the switch e. The ammeter g enables the operator to determine whether the pump is working properly or not. f is a pilot lamp which burns when the pump is on. a, t, d are fuses.

The motor starter M is connected as shown. n and o are the terminals of the coil r, which is connected in series with the shunt field of the motor. P and Q are the terminals of the starting resistance, which in starting is in series with the motor armature. When current is switched on, the coil r pulls up on its moveable core t, which carries the short-circuiting arm n which in turn cuts out the starting resistance. s is a sort of a dashpot which, to a certain extent, counteracts the coil r, causing the short-circuiting arm n to rise slowly, allowing the motor to make an easy start.

The valve W and switch H are used only when it is desired to raise the pressure in the mains, as in case of fire.

It is evident that when the valve W is closed the pump will be pumping directly into the mains. The pressure is limited by a relief valve on the discharge pipe of the pump. x and y are the terminals of the coil, which operates the valve, and are connected as shown. The valve being opened and closed by the switch a. b is a lamp in series with the valve circuit.

The pumping circuit was not installed heavy enough for pumping fire pressure, so the switch H was mounted and connected as shown. i and j are the terminals of the coil which operate it. It is controlled from the power station by the switch c.

One can readily see that in case of fire but a moment's time is required to get the pump started and have it pumping fire pressure. Also, that quite a saving was made in the operating cost, as both the power plant and the waterworks are owned by the city.

The outfit has also been very reliable and up to the present time the steam pumps have not been called upon to help out. A. A. Stiehl.

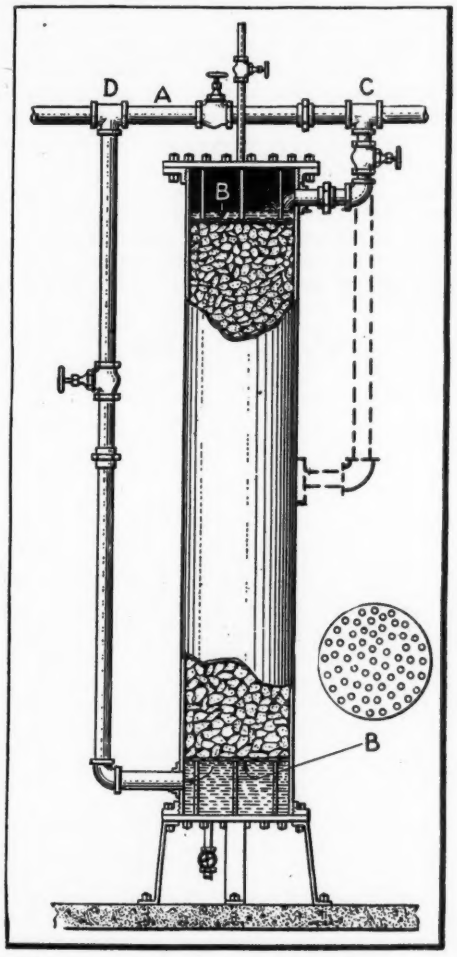
FEED WATER FILTERING

I ENCLOSE sketch of a filter which was made some years ago and which I connected as shown in the full lines. The filter consists of a 6-ft. length of 10-in. pipe threaded at both ends and with regular standard flanges screwed on. Two blank flanges were used as heads, these being bored and tapped for ½-in. pipe, one used for draining oil out at the bottom and one for blowing out at the top. Two flanges were riveted on the sides, one near the top and the other near the bottom for feed water to enter and leave. Also 2 screens were made, as shown at B, with 3 legs 6 in. long. These screens were the same diameter as the pipe, 10 in.

After getting all connected together, except the top cap, I put one of the screens in the bottom and filled with coke broken to about the size of an egg up to about 6 in. from the top, and put in the other screen which is to prevent the pieces of coke from floating up into the feed line. I then put on the top cap, opening the valves on the filter and closing the valve on the old feed line A, and the filter was working.

Water enters at the top through the tee C, passes through 5 ft. of coke and up into the old feed line

through the tee marked D. I found that the majority of oil deposited on the coke found its way to the filter during the night and in this way I can keep the filter clean during a longer period than if the filter were not blown out. It practically took out all the oil from the condensed returned steam, so that the boiler was kept clear. I understand that one of the insurance companies has recommended that the filter be connected as shown in the dotted line, and that it has been done. It seems to me that half the filter has been made useless, and I would like to hear the opinion of others. If I am wrong I want to be shown why.

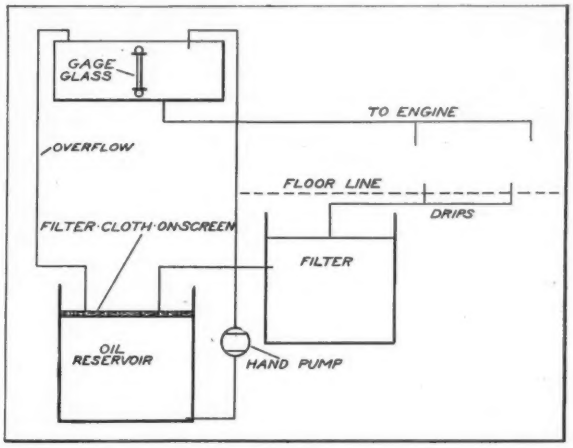


THE HOME MADE FILTER. WHICH CONNECTION IS RIGHT?

John Mitchell.

TROUBLE WITH OILING SYSTEM

THE first sign of trouble was the gage glass on the overhead tank filling to overflowing when the oil was pumped up by the hand pump from lower tank. As we knew there was not enough oil in the system to fill overhead tank to overflowing, we concluded there must be something wrong. After about 15 or 20 min. the gage glass was completely empty, yet the oil was flowing freely to the engine bearings. We were puzzled for some time before we discovered the trouble. The chief engineer investigated, and this was what he found. The pipe that leads from the overhead tank to the lower oil reservoir, which serves as an overflow and air relief, had become stopped up at the lower end by the oily filter cloth that lays on a screen there. This made the overhead tank air-tight, except for a little vent hole at the top of the gage glass. As the oil was pumped up into this tank the air inside was slightly compressed, forcing the oil up higher in the glass than the level in the tank. Then as the oil flowed to the engine bearings the oil in the tank lowered, and as the tank was now air-tight, a partial vacuum was created, drawing the oil from the glass back into the tank, completely emptying the glass. After cleaning the lower end of the overflow pipe and shortening it a few inches so as to avoid a repetition of the affair, the gage glass always showed true level of the oil in the tank, and we had no further trouble with our system.



ARRANGEMENT OF OILING SYSTEM

Frederick M. Perras.

STARTING THAT CORLISS ENGINE

IN the July issue, Mr. Wakeman's article on starting the Corliss engine seems faulty. The question was asked in the April issue and is a pure and simple one. Stating plainly that both steam valves are closed. In such a case it would be necessary to unhook the rod from the eccentric and open the steam valve to admit steam to the cylinder, then open the throttle valve and connect on the hook rod as the engine started. The question is simple and correct, but Mr. Wakeman claims it is incorrect. I will not attempt to discuss the misleading points of his article, but would like to ask Mr. Wakemam how late a single and also a double eccentric Corliss engine will cut off?

It seems to me he has omitted one most important point in his study, the duty performed by the eccentric. For in setting a single or a double eccentric Corliss engine with direct connected and direct acting valve gear, the eccentric is placed 90 deg. plus the lap and lead in advance of the crank, which is about 120 deg. of the circle of revolution. Now, if the crank travels ¼ of a revolution to bring the piston to the center of the cylinder, the eccentric has traveled to its point of extreme throw, or more than ½ a revolution from the starting point of the crank. The valve would not only have been opened full, but with the governor in the starting position the valve would have been tripped and closed by the dashpot.

If this did not happen on a single eccentric Corliss engine the release would be very late or release

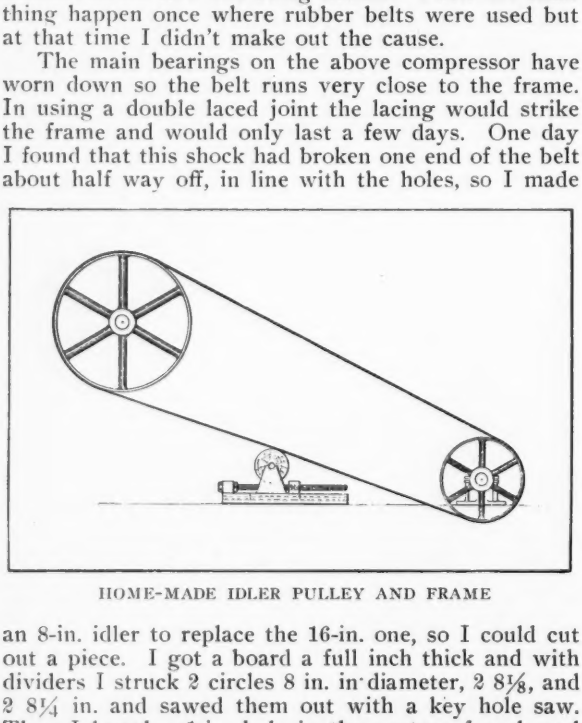
not occur at all, as the exhaust valve would be closed on the opposite end for compression and the return stroke would simply reverse the operation to the opposite end of the cylinder. If the valve did not close by the time the eccentric reached the point of extreme throw (½ revolution) it would require another ½ revolution of the eccentric to push it shut. Such an engine, considered from a point of economy in steam consumption, is no better than a slide valve engine. Why are 2 eccentrics used on a Corliss engine if one will hold the steam valves open so as to start with the piston already at half stroke? It is to get a later cut off without the excessive compression which accompanies an engine with a single eccentric, i. e., where the exhaust valves are operated by a separate eccentric the steam valves can be changed at will without changing the compression.

If Mr. Wakeman's engine will keep the steam valves open at ½ stroke there is something materially wrong with the valve gear and governor connections, and an indicator card taken from an engine operating in the manner he has mentioned will be very interesting study. For a double eccentric engine with a range of cut off from zero to 2/5 stroke is only made later by specially adjusted steam rods and moving the eccentric back an amount equal to the shortening of the rods. R. A. Cultra.

IDLER PULLEYS

NOT long ago I replaced a double leather belt, that is used to drive an ammonia compressor, with a new, double leather one. I laid the old one on the floor and took pains to cut the new one the same length. On putting the new one in place I was surprised to find it a very tight fit, with the idler drawn clear back, while the old one was loose with the idler pushed up. After some study I concluded it was on account of the new one being thicker. I saw the same thing happen once where rubber belts were used but at that time I didn't make out the cause.

The main bearings on the above compressor have worn down so the belt runs very close to the frame. In using a double laced joint the lacing would strike the frame and would only last a few days. One day I found that this shock had broken one end of the belt about half way off, in line with the holes, so I made



HOME-MADE IDLER PULLEY AND FRAME

an 8-in. idler to replace the 16-in. one, so I could cut out a piece. I got a board a full inch thick and with dividers I struck 2 circles 8 in. in diameter, 2 8⅛, and 2 8¼ in. and sawed them out with a key hole saw. Then I bored a 1-in. hole in the center of each and after thoroughly soaking I nailed the 2 largest pieces together, with the grain crossed and the holes in line, then I nailed one of the next largest on either side with the grain opposite to the one under it; this I repeated with the 2 small pieces, next I took a wood rasp and trued the pulley up, and on driving in a piece of ¾-in. pipe for a shaft I had an excellent pulley.

The frame for this idler is home-made. Two A-shaped pieces for the sides, with half round cavities on top for the shaft, these sides being spliced to a piece of plank which slides in a frame, 2 long screws being provided to move it up. I have decided to replace the lacing with belt hooks, and will have to cut off the lace holes, so I will have to make a real small idler and if necessary reduce the height of the side pieces.

Perhaps some of the readers can make use of such an idler in case a belt breaks. One can make as high a center as desired, but I find the one named above gives good satisfaction, the idler staying under the belt and running true. Fred Eckley.

INJECTOR TROUBLES

IN regard to H. E. H.'s injector troubles, which appeared in the June issue, I do not think he has the proper injector, or if he has, it is not properly connected to the boiler. Inasmuch as he has not given the name of the injector used, I am assuming it to be an automatic lifting injector.

The suction pipe may be stopped up and prevent the injector from raising water. This is generally due to a clogged strainer or to the pipe itself being stopped up at some point. This prevents water from coming through and is probably the most frequent cause of an injector not working. The best thing to do is to blow steam back through the suction line and force out the obstruction. Leaks in the suction pipe will admit air and prevent the injector from forming the vacuum required to raise the water. In testing the suction pipe for air leaks with steam the end must be plugged and the overflow valve must be held to its seat in some manner or the overflow must be made tight. It is best to have the suction pipe full of water before turning the steam on, since the presence of small leaks will be revealed better by water than by steam. After testing, be sure to clear the overflow and suction.

In some cases the water in the suction pipe is too hot and the injector refuses to handle it. The reason of this is that the temperature at which water boils depends on the pressure to which it is subjected. It has been determined, by experiment, that water will not boil at 380 deg. F. under a gage pressure of 180 lb.; at 212 deg. F. when subjected to atmospheric pressure or about 14.7 lb. per square in., and at about 190 deg. F. when in 10-in. of vacuum. This shows that decreasing the pressure on the water lowers its boiling point. Now, when the lifting jet of an injector is turned on, a vacuum is formed in the suction pipe; and if the water is at a temperature of 150 to 180 deg. F., it gives off vapor which fills the suction pipe and destroys the vacuum. The water should be cooled in any convenient manner, and at the first opportunity trace out the cause.

In some cases an injector will lift water, but will not force it into the boiler; or it may force part of it into the boiler and the rest out the overflow. The boiler check-valve may be stuck shut. If completely closed, the injector may or may not continue to raise water and force it out of the overflow. It depends on the design of the injector. If the boiler

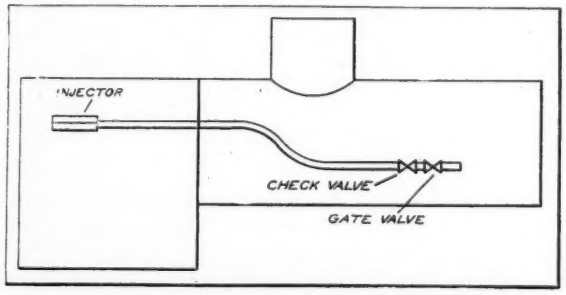
check is partly open and the injector does not work, the boiler should be cut out and the checks examined, unless there are 2 feed connections, in which case wait until an opportunity presents itself, but it should be looked after without delay.

It may be that you are trying to work the injector to its maximum capacity. Thus if the injector is worked at its minimum capacity with a steam pressure of 30 lb. the temperature of the water delivered to the boiler will be about 114 deg. F.; if the pressure is 200 lb., the temperature of the water delivered will increase as the delivery of the injector decreases. Thus under 140 lb. steam pressure, and working at its maximum capacity, an injector may deliver water at about 135 deg. F., while if the injector is cut down to its minimum delivery, the water will be delivered at about 250 deg. F. Under ordinary working conditions, the water is delivered at a temperature about 160 to 200 deg. F. The highest temperature at which an injector will lift the feed water decreases as the steam pressure under which an injector is working is increased. At low pressure the injector may raise water at 125 or 130 deg. F., while at 140 lb. and upwards it is not safe to have the water much above 112 deg. F.

Benj. F. Maddox.

IN regard to the injector trouble of H. E. H., I would suggest that he change his piping to conform to the enclosed sketch, as it is inadvisable to put more check valves and elbows than necessary between injector and boiler. I also notice that one of his inlets discharges near the rear tube sheet, which is one of the hottest places in this type of boiler. I would consider this bad practice, as it might cause the sheet to leak. Following are a few suggestions which might help H. E. H. if he has trouble with his injector breaking:

The steam supply pipe should be the full size called for by the injector, and preferably should be connected



INJECTOR PIPING FOR LOCOMOTIVE TYPE BOILER

directly into the steam space of the boiler so it will have a steady flow of steam without sudden variations of pressure.

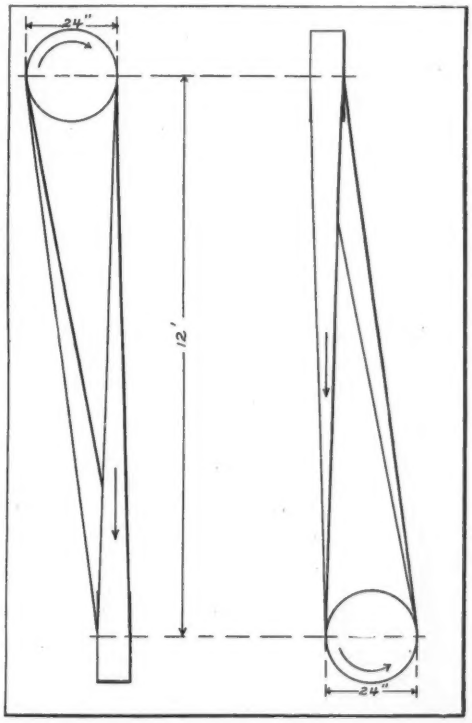
The delivery pipe should be of proper size and should have the least possible number of elbows and other fittings in order to keep the friction loss low. For this reason it is also better to use long sweep bends if possible.

It is better to use swing checks than vertical lift checks, as there is less friction to the liquid passing through them.

If the injector is lifting, particular care should be exercised to see that the suction pipe is perfectly tight, as even the slightest amount of air entering will cause the injector to break; it will also seriously impair the lifting power. Another possible cause of trouble is that H. E. H. may be trying to handle hotter water than the injector was designed for. To get directly to the question asked, I do not think the 2 checks alone cause the trouble. It is probably caused by the combination of 3 90-deg. ells and 2 checks and possibly by an unsteady steam supply. O. J. Richmond.

QUARTER TURN BELT

IN the devices shown in the July issue for training quarter turn belts I noted the drawing shown by Mr. Kunkle in which he says it runs like a clock, but I think he will agree with me that it requires some power to run those 2 12-in. idlers at 500 r. p. m. and also make a quarter twist on a 6-in. belt running 1500 ft. per minute on about 6 ft. centers, and I dare say if Mr. Kunkle would put a brake on his shaft he would be astonished at the amount of power he has wasted during the last 12 months in compelling that 6-in. belt to run out of its natural course, to say nothing of the constant care these 2 idlers require when by simply moving the driven pulley the diameter of the driver the belt would run like a clock without any idler, and



SIMPLE AND MOST ECONOMICAL QUARTER TURN BELT ARRANGEMENT

instead of the quarter turn being made in about 6 ft. it would have 12 ft. which, of course, would require less power and be less torsion on the belt.

If the quarter turn pulleys are set according to the sketch the belt will run splendidly on 12 ft. centers of shafts, especially, as in his case, both pulleys are same diameter, a properly arranged quarter turn belt will run in one direction only as the belt will leave the pulleys if the shaft is turned backward. Owing to the angularity, the pulley should be from 2 to 4 in. wider than the belt.

I presume that all engineers will agree with the writer that an idler frame in an engine room or any other prominent place is not much of an ornament no matter how nicely it is gotten up, and is only to be tolerated when absolutely necessary for tightening purposes or carrying slack belts. W. S. L.

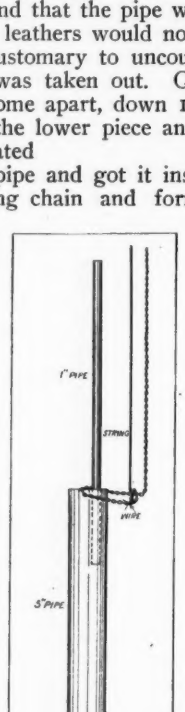
DEEP WELL PUMPING

ONCE upon a time I was at a place where we had a well 60 ft. deep and 8 ft. across. The water stood 50 ft. deep, normally, but could all be pumped out in 9 hr. The pump had a single acting plunger, driven by a small gasoline engine. The pipe was 5 in. in diameter with a 4 in. cylinder fastened inside with a wedge ring.

A strong platform was put in the well at the surface of the water, a cast-iron plate laid on this, and the pipe screwed into the plate. A second plate was bolted on top, carrying a stuffing box.

One day the pump refused to work, so I decided to take out the plunger, and put on new leathers, but on pulling it up I found that the pipe was reduced to 4 in. at the top and the leathers would not come through. I was told it was customary to uncouple the pipe every time the plunger was taken out. On raising the pipe we found it had come apart, down 16 ft. Then it was a puzzle to catch the lower piece and get it out. This was done as illustrated

I took a 1-in. pipe and got it inside the large pipe, then we took a long chain and formed a small loop



CATCHING PIPE IN WELL

around the chain and fastened the end with wire. Then we made a large loop and tied 2 links together with a string, making a single slip loop in such a way that on pulling the string it would come untied. Placing this large loop around the small pipe we lowered it until it hung down over the large pipe, as shown. Then on swinging the small pipe in a circular way I made the chain drop down around the large pipe, and on pulling the string loose the loop closed and we had it fast. We could not get any blocks to lift it, so we made use of the engine, it being geared back about 11 to 1. We fastened a rope to the chain, passed it over a pulley hung on the ceiling and wrapped it twice around the gear wheel's shaft. One man held the end of the rope, keeping it drawn tight, while two of us turned the engine, the suction valve being open to prevent compression.

On wrapping around the shaft the rope would naturally work along till it got to the bearing, then we would hook a second chain to the first, to support the weight, while we slipped the rope to the other end of the shaft. On getting the pipe out we found it was reduced to 3 in. at the bottom, we took off the small piece and tied screen on for a strainer. We also had the top plate cut out to take a 5 in. pipe. It is needless to say that this was a Government installation and the work had been done by contractors. The reservoir on the hill was 23 ft. across and was half a foot lower on the back side, than it was at the outlet. Fred Eckley.

PUMPING FROM LAKE

IN reply to the pump troubles of E. T. in July Practical Engineer, I would say his inquiries are vague, as he does not state the height of the suction lift or give the size of plungers or length of stroke in triplex pump.

The undertow, if any, would not affect suction in the lake.

Not knowing the size of pumps or if discharge line has fall or gravity one cannot tell if the pump can hold pressure.

The combined area of the 3 5-in. lines is only 58.9 sq. in., the area of the 10-in is 78.54 sq. in., and discharge 8-in. area is 50.26 sq. in. The suction is undoubtedly too small, extend the 10-in. direct to the lake with a foot valve, and avoid all ells and bends possible. If you have not an air chamber or suction line that would help. C. E. Aldrich.

AN ELEVATOR OUTFIT

WE have in this building 3 Kieckhefer hydraulic elevators of the cable hoist type, 2 being used for passenger service and the third for freight and as an auxiliary. They are rated at 2500 lb. capacity with floor area of 38.5 sq. ft. These cars run to a height of 175 feet at a speed of 600 ft. a minute and have 12 landings each.

These cars are operated by a lever at the right of the operator and I have found this method of operation to give better satisfaction in breaking in new men than where the lever is at the left.

Hoisting beams are steel ell beams 5 by 12 in. bolted direct to the beams of the building frame. The sheaves on these machines are 36 in. diameter by 4 in. face, 12 on each machine carried on a 4 in. steel shaft. Each sheave has a brass bushing ⅜ in. thick and solid brass collars between the sheaves.

When these machines were installed the bushings and collars were filled with graphite, but we soon had trouble with them, as the collars would split and pieces

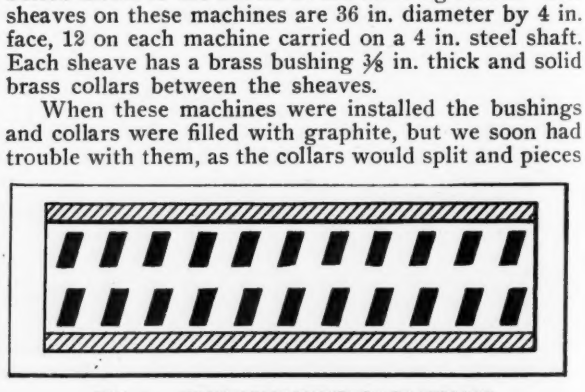


FIG. 1. GRAPHITED BUSHING OF SHEAVE

would fall down among the sheaves and the deuce was to pay. The graphite in the collars got out and worked up into the oil holes, and I had to drill it out.

As fast as any repairs were made on any of these sheaves the graphite collars and bushings were sold to the junk man and good solid brass took their places.

On these machines we have 4 hoisting ropes ⅝ in. diameter of Swedish iron, and 2 counterweight ropes same size, making 640 ft. of right hand and 640 ft. of left hand cable on each machine. The hoisting ropes wear about 3 years and the counterweight ropes have been

in service nearly 10 years and show hardly any wear.

We used a compound on these ropes at first, but the tenants of the building wanted to know if we were going to turn the building into a tar kettle, so we quit it and have been using cylinder oil since that time.

These ropes are shackled to adjusting bolts on the machine and are shackled through a double cross beam on the top of the car.

These adjusting bolts are going to come out and good strong turn buckles with lock nuts are going to take their places as soon as I get a chance to install them.

We have the cylinders horizontal in triple deck arrangement so that one machine is on top of the other and all shoved into a dark hole, where you can't get at them. This condition was, of course, brought about by the architect trying to save room, and he succeeded.

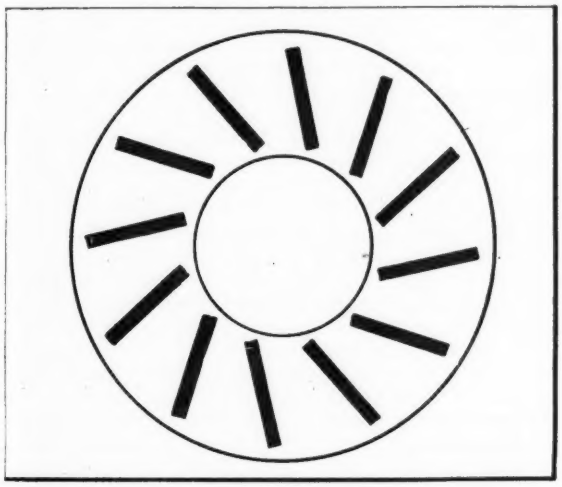


FIG. 2. END VIEW OF GRAPHITED COLLAR

We all know and the architect knows that an elevator is a machine that will run for years without any attention, and the best place for it, like the average feed pump, is in some hole out of the way, back of some wall, or any place where you won't have to get a ladder to get over it and soil your nice clean overalls.

I believe that an elevator should be placed out in a room well lighted and ventilated, where it can be kept clean and looked after at all times; not in a hole where a man seldom goes unless he goes on the run when something is wrong. The time to go is before anything goes wrong.

Our pressure tank is 72 in. diameter and 16 ft. long, with bumped heads and carries a pressure of 120 lb. It has a relief valve and will blow direct back into an open tank.

We have 2 steam pumps, a tandem duplex compound 14 by 20 and 12 by 18 in. and a simple duplex 16 by 12 by 8 in. They are good pumps for a place where the plant has a machine shop and foundry of its own. We know that when the devil wants a place to hide, he most always goes into a pump, and we have to yank him out of ours altogether too often.

A. E. M.

THE LIGHTER SIDE

DUTIES of engineers are by no means conducive to humor or the nonsense of everyday life. Still we are not such highbrows but what the humorous appeals to us, especially when it concerns our work. In view of this I offer the suggestion that in the pages of Practical Engineer some space be devoted to such happenings each month*; the material to be furnished by subscribers, and all stories to be in some way related to the power plants. As a starter I offer the following:

The large plant of the P——— Co., was being made much larger to meet the increased demand for light and power. Nearly all the various machines of the new equipment were installed and many already in operation.

On this occasion I was talking with one of the firemen, a superstitious Irish lad at the far end of the old boiler room, and directly to one side of us was a large hole in the floor. Suddenly our conversation was interrupted by a muffled explosion and clouds of dense smoke pouring from the hole. Well we both jumped a couple of feet vertically and when I came to the fireman was beating it down the boiler room like a skyrocket. I rushed down stairs to find the cause; I found it, but kept my mouth shut.

That night in the locker room one of the steamfitters came in limping and wearing an expression that was anything but pleasing. The boss elevator machinist inquired. "What's the trouble with you Bill?"

Whereupon Bill the fitter pealed off some language not usually printed and declared, "A boiler or somethn' was getting ready to blow-up and while I was trying to discover a quick way out, I fell into the sump pit."

Just then one of the oilers piped:

"Why, that wasnt anythin' blowed up Bill; that was a photographer takin' a flashlight of the contact-room!"

In the same plant the coal conveyor operator is supposed to keep the boilers free of soot. Also he is not supposed to drink while on the job. But this one did, much to the dissatisfaction of the assistant chief. The latter claimed that there was such a difference of Sp. Gr. between steam and whiskey that they would not properly mix. As the operator's breath was usually stronger than the gases when the damper is closed and the blower on full, you see he didn't pull good with the assistant chief.

One day the said A. C. went around to the back of the boilers and opened one of the rear doors. No sooner had he done so than his nice new suit was covered with hot soot. Slamming the door shut, or nearly so, he dispatched one of the cleaners to hunt up the conveyor operator, who, in due time, arrived, turning blue when he beheld the soot-covered chief, and bluer still as the latter injected a volume of patented cuss words into him, demanding to know why those boilers were full of soot.

"Well, Mr. ———," says the operator. "They—they—they're too full to be emptied."

C. H. Bromley.

*The editors agree and will be glad to have short stories along this line.

THE LAGONDA AUTOMATIC cut-off valve, made by the Lagonda Mfg. Co., Springfield, O., is the only valve which has been admitted, up-to-date, to the Museum of Safety Devices, which is maintained in the Engineering Societies Building, 39 West 39th Street, New York. The valve, as described, in recently issued circular matter, is made to close automatically if a break occurs on either side of the valve. The circular describes some tests made at Washington in January, 1909, in which a 4-in. valve was used, showing the reliability of the mechanism.

ECONOMY IN AIR COMPRESSION

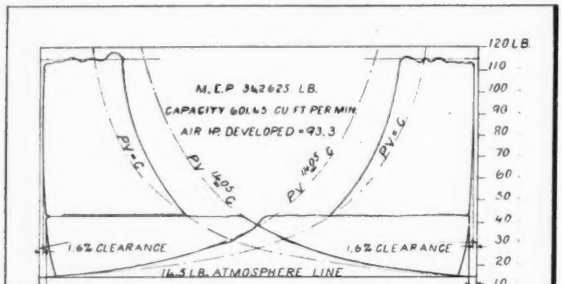
By L. J. Wightman

IT is perhaps unnecessary to say that it is almost as important that air should be admitted into the cylinder cool as that it should be kept cool during compression. If a water jacket were not used the entering air would be heated while passing through the hot valves and ports and by contact with the heated interior of the cylinder. This would mean the rarification of the intake air, reduced cylinder capacity, lower efficiency of compression and excessive terminal temperature.

Since jacketing is at the best only partially effective, this latter argument suggests the advantage of those constructions which admit air through one or at least only a few large openings where only the outer film of the air is heated, rather than through a number of smaller openings through which the air is finely subdivided and heated.

Stage Compression

THE second process of cooling—compression in stages—is analagous to an arrangement in which the compressing piston of a single cylinder is stopped at intervals through its stroke, and the partially compressed and heated air is withdrawn and cooled by some external means to its initial temperature or



CARD SHOWING EFFECT OF INTERCOOLING

even lower; then returned to the cylinder to be further compressed, heated and cooled until the desired pressure is reached. It is evident that such an arrangement would maintain a fairly uniform low temperature in the air volume throughout the stroke, giving very close to isothermal compression.

Such a proceeding is evidently not practical. But the same results may be obtained by compressing in several cylinders, in the first of which moderate pressure and temperature are reached and the air in this condition discharged through a cooling device which restores its initial temperature; then admitted to another cylinder for further compression and heating; again withdrawn and cooled and again compressed. This is stage or compound compression.

Average practice of the leading builders permits single stage compression for pressures up to 70 or under some conditions to 100 lb.; 2-stage compression for pressures of 75 to 500 lb.; 3 or 4-stage (preferably in duplex compressors) for pressures of 500 to 1500 lb.; and 4-stage compression for pressures from 1500 lb. up.

A 3-stage straight line machine should be used only for small or moderate capacities. Above this, the duplex type should be preferred because of its balanced construction and of the readiness with which it is compounded.

Intercooling

PRIMARILY the object of compound compression is saving in power required by what may be called the heat element in compression. The degree to which this is accomplished depends entirely upon the efficiency of the intercooler. The ideal intercooler would be one which would reduce the temperature of the air to the temperature of the cooling water, and a good practical standard demands a reduction to not more than 10 deg. above the cooling water.

Successful intercooling involves 6 fundamental requirements; 1, it must provide for a complete and minute subdivision of the air so that the heat may be dissipated without any dependence upon the heat-conducting qualities of the air itself; 2, the air should be split up into thin sheets or streams so as to dissipate its internal heat, and ample cooling surface must be presented to this subdivided air stream; 3, the circulation of the cooling water must be properly directed in relation to the flow of the air, and its velocity must be such that the maximum amount of heat will be carried away without waste of water; 4, all air passages must have ample cross section, that the low velocity of air may give sufficient time of contact with the cooling surfaces for the complete removal of the heat; 5, expansion and contraction must be so provided for that there will be no leakage of air or water; 6, suitable means must be provided for removing form the intercooler the moisture condensed from the air in the cooling process.

Other Advantages of Stage Compression

COMPOUND air compression has important bearing upon other features of compression economy. It reduces the average structural stresses, resulting in a higher factor of safety and a longer life for the machine with a given weight of metal. The maximum stresses encountered in compression in 2 stages are only 55 to 60 per cent of what they are in single stage compression to the same pressure. The reduction of stresses here referred to is felt not only in the machine structure but in the air valves, which show a notably easier operation under compound conditions.

Another advantage of compound compression is an improved steam economy if the compressor is steam driven. The averaging of stresses throughout the stroke permits the work to be done with a lower m.e.p. in the steam cylinder, which means a shorter cutoff and a greater steam economy. The reduced terminal stresses permit a higher piston speed with safety, thus improving the steam economy by reducing condensation losses and leakage in the steam cylinder.

Higher volumetric efficiency results from compound compression, coming from 3 sources. The first of these is the fact that the clearance pressure in the intake cylinder is lower. The second is a lower maximum temperature in the cylinders so that the entering air is not so much heated. The third is a reduction of leakage consequent upon the reduced extremes of pressure in each cylinder.

Compound compression results in more efficient lubrication of the machine because of the lower temperatures involved. This means easier running, im-

proved mechanical efficiency, less wear, lower repair costs, reduced leakage losses, and longer life. Compresion in stages results in the delivery of drier air—a feature of great importance where the air is used under conditions which may result in freezing up at the exhaust ports. This also largely obviates the accumulation of water in pipe lines.

Air Valves

AIR valves of a compressor are probably the most vital parts of a machine. While the number of different types of air valves is greater than the number of compressor builders, yet they may be broadly classified into 2 groups. Mechanically actuated valves have a positive motion derived through some mechanical connection from the rotating or reciprocating parts of the compressor. Poppet or automatic valves are operated wholly by differences of pressure.

Some air valves in use today canot be exactly placed in either class, notable among which is the Hurricane-Inlet or Piston Inlet of one of the large builders, which is operated by its own inertia. In other cases a valve may seem to combine the features of both classes, an automatic adjustability supplementing a primary mechanical control.

Inlets

THE function of an inlet valve is to admit the maximum volume of cool, clean air to the cylinder with the least expenditure of power; to keep this air in; and to continue to perform this duty indefinitely at the least total cost. Analysis of this function reveals the following requirements of the successful inlet valve.

It must admit a volume of air which will entirely fill the cylinder, this air being as nearly as possible at atmospheric pressure. This calls for an instantaneous and complete opening of the valve, so timed that there shall be no escape of the compressed air in the clearance space, which full opening should be held to the end of the stroke; and short, direct and unobstructed passages should be provided through ports and valves.

It must admit clean air, suggesting a design permitting ready connection to an intake passage or conduit leading to a place free from dust and grit. The air admitted must be as cool as possible—a condition partially met by the consideration just mentioned, by which cool air as well as clean air should be supplied. But, more than this, the cool air supplied should nowhere be heated in its course into the cylinder, suggesting that valves, ports and passages shall be so placed as to be cooled by the cylinder jacket. Moreover, the air should be admitted through one or a few large openings rather than seived through many small ones.

All the air admitted must be kept in the cylinder, calling for instantaneous and complete closing of the valve at the end of the stroke, with a perfect seating and without any leakage. All the processes outlined here must be carried on with the least possible expenditure of power for the overcoming of friction and the manipulation of the valve gear—a requisite demanding nice adjustment, simplicity of mechanism, perfect lubrication and as few wearing surfaces as possible. Such exacting performances must be continued indefinitely, twice each revolution and hundreds of times per minute without undue wear or loss of adjustment. This condition calls for correct design, high class materials and workmanship, and generous lubrication.

The ideal inlet valve is here outlined. Probably no compressor valve on the market today exactly fulfils all of these conditions; but many types represent the experienced judgment of the builders applied in an excellent compromise.

Discharge

FUNCTIONS of an air discharge valve are to release the full volume of compressed air from the cylinders with the least friction and power expenditure; to keep it all out after discharge; and to continue indefinitely to maintain this duty without undue expense. The primary essentials of such a valve are as follows:

Its opening must be full and instantaneous, must occur at just the right point in the stroke and must be held until the piston comes to rest. The valve opening must be ample so that the velocity of discharge may not be excessive; and the ports and discharge passages should be short and free from obstruction, to reduce friction.

As few parts as possible, and these correctly adjusted, should provide for the necessary valve movement with the minimum loss of power in mechanical friction.

The valve should close instantly and completely as soon as the piston stops, so that there may be no return of the air discharged when the piston starts on its back stroke, as such a return of compressed air would have the effect of an increased clearance, reducing the capacity of the cylinder.

Continued maintenance of this performance (which is more arduous upon the discharge valves than upon the inlet valves because of the higher pressures) suggests the advisability of a simple construction with the fewest bearings, careful workmanship, the use of good materials, perfect lubrication and careful distribution of materials.

It is always to be remembered that discharge valves and ports are continually exposed to a flow of heated air even where jacketing is most complete. On the other hand, an essential of inlet valves and ports is that they shall be kept cool. The latter should therefore be removed as far as possible from the former; nor should the same ports be used for both inlet and discharge.

Valves and Passage Areas

IT might at first glance seem that the area of the discharge valves, ports and passages could be much less than the corresponding inlet area, since the former must pass the air at a higher pressure and in less volume than the latter. But it is to be remembered that while the inlet areas are open during the full stroke, the discharge areas are open for only a part of the stroke—about one-third. In order, therefore, to make the velocity of discharge about the same as that of intake or admission, it is usual to make the inlet and discharge areas approximately equal.

It is important that the velocity of flow through valves, ports and passages shall not be excessive; and this depends upon the piston speed, which is a widely variable quantity. The higher the piston speed, the larger should be the area. In actual practise, the inlet area varies from 3 to 15 per cent of the cylinder area, with an average probably around 9 or 10 per cent. The corresponding discharge areas vary from 7 to 15 per cent, with an average in the neighborhood of 10 or 12 per cent. The larger these areas, the better the economy.

Owing to the increased friction through a number of small passages as compared with that through a single large one, the actual measured area in the former case should be 50 to 100 per cent larger than in

the latter. This explains why the measured inlet area of machines with Corliss or other large area inlet valves is often so much less than the measured discharge area of many small poppet discharge valves, while still giving good results.

It may be well to recall at this point that cylinder clearance is really made up of 3 elements: The inlet port clearance, which is all the space left between the closed inlet valves and the inner surface of the cylinder; the discharge port clearance, which is the corresponding space in the discharge passage, and the piston clearance, which is the space allowed for safety between piston and cylinder head at the end of the stroke. This latter element is an essential in all compressors. But it is not unusual for the other 2 elements together to constitute by far the larger proportion of the total clearance. This suggests the superiority of those valve designs in which inlet and discharge port clearance are reduced to the lowest practical limit.

EXPLOSIONS OF AIR COMPRESSORS

Increase of Temperature Due to Leaking Exhaust Valves Causes Deposit of Carbon Which Ignites and Heats Pipe to Red Heat. Remedies Offered.

By Charles H. Garlick

More lives are lost and property destroyed through explosions of air compressors, than through boiler explosions in proportion to the number of each that are in service. Frequently, explosions of air compressors and their connections are attributed to the oil used in the lubrication of their cylinders. Yet oil can only be a contributing cause to these explosions, and very rarely is even that.

In the compression of air, heat is generated. For instance, if air is admitted to the cylinder of a compressor at the pressure of the atmosphere and at a temperature of 60 deg. F., and then compressed to a pressure of 100 lb. to the square inch, it would attain a temperature of 447 deg. F.; if compressed to a pressure beyond 100 lb. to the square inch, a correspondingly higher temperature would be reached. To prevent these high temperatures, the cylinders of air compressors are surrounded by an envelope or water jacket through which water is kept continually flowing, thereby absorbing a considerable portion of the heat generated by the compression of the air.

When the compressor is in good working order and compressing air to 100 lb. to the square inch, the air leaves the compressor at a temperature of about 200 deg. F. Should, however, the exhaust valves on the compressor leak or stick, the air leaving the compressor at a temperature of 200 deg. F., will not all find its way to the receiver, but a considerable quantity of it will return to the cylinders through the leaking exhaust valves. This air returning to the compressor at a temperature of 200 deg. F., instead of 60, as it did at first, will, when again compressed, attain a temperature of probably 250 deg. F. This air at a temperature of 250 again returns to the compressor and is again compressed, this time to a higher temperature than before. The continual "churning" of the small quantity of air that passes the leaking valve, will in time heat all the air being compressed to a temperature of 500 deg. F. and over, despite the fact that cold water is continually passing through the water jacket.

Every explosion of air compressors that I have investigated, has been preceded by a period in which the compressor was working badly. When the machine works badly, the attendant usually admits more oil to the cylinder, as the oil comes in contact with the air at a temperature of 500 deg. F. and over, much of it is vaporized and the residue adheres to the inside of pipe leading from compressors to the receivers. I have seen this pipe filled with carbon to such an extent that the area of the pipe was reduced 50 per cent.

The continual churning of the air may cause it to attain a temperature of 700 or 800 deg. If the pipe carrying the air contains carbon, it will ignite; the pipe becomes red hot, thereby reducing the tensile strength of the steel or iron to such an extent that the pressure of air inside the pipe will cause it to burst. Yet I have seen pipes leading from compressors to receivers that had burst, that did not contain a particle of carbon. Where the pipe contains carbon, high temperatures have prevailed for several days at least.

Every explosion that I have investigated has left on the pipe unmistakable evidence that it had been red hot. In addition to leaking valves being the cause of the air becoming heated, it has been learned that where the exhaust valves have not been given sufficient lift the air in the cylinder in its effort to escape by the small opening in valve, attains a pressure and corresponding temperature 3 or 4 times as high as the pressure shown in the pipe beyond the compressor.

To sum up, every air compressor explosion I have investigated has been caused by an abnormal temperature of the compressed air. This high temperature has been due to the failure of the valves to operate properly. The use of even large quantities of oil in the air cylinder has not in itself, caused any explosions, but has been in some cases, a contributory element by depositing carbon as noted above.

If the following recommendations were put into effect, an explosion from heated air could not occur. No oils other than those made especially for air compressors should be used, and they only in small quantities.

The receivers should be blown off from the bottom every 24 hours. The receivers should be open once a month and if it contains any oil, it should be removed.

The pipe leading from the compressor should be examined every 3 months to see if there has been any deposit of carbon in it.

A thermometer similar to those in use on economizers should be placed in the air line just above the compressor. I consider a thermometer on an air compressor just as necessary as a steam gage on a boiler. If there is a thermometer on the line the compressor attendant will soon note when his machine is working properly, that the temperature of the air as it leaves the compressor at a pressure of 100 lb. is about 200 deg. F. Should it gradually go above that, he should ascertain the cause. Should it suddenly go considerably above that, he should stop the machine. To make an explosion from hot air absolutely impossible a soft plug similar to those used in boilers, and which will melt at a temperature of 400 deg. F., should be placed at some convenient point in the air line between the compressor and the receiver so that, should the air through carelessness or any other cause become heated to a temperature of 400 deg. F., the fusible plug will melt and let the air escape.

Homestead Valve Mfg. Co., of Pittsburg, has changed its Chicago agency and its product will in future be handled by the McMaster-Carr Supply Co., 166-168 W. Lake St., Chicago. This company will act as agents for the states of Illinois and parts of Wisconsin and Iowa. A large stock of Homestead valves will be carried and orders for special valves not carried in stock will be shipped promptly direct from the Pittsburg factory.

DRAFT*

NEW METHOD OF DETERMINING THE HEIGHT OF CHIMNEY NEEDED TO GIVE REQUIRED DRAFT AREA FOR GIVEN BOILER HORSEPOWER

By Henry G. Brinkerhoff

THERE ARE ONLY 2 dimensions to be detremined, the height and the area, and we will consider first the matter of selcting the chimney height. A proper height is of the greatest importance as this produces the dependable pulling force, which must be sufficient to overcome friction; through the grates, a quantity that varies according to design and percentage of air opening. Through the coal, which depends upon its depth, quality, tendency to clinker and the intelligence of the firemen; through the boiler, which is greater or less according to its general type and bafflings; through the flues and chimney, which is affected by their size and shape as whether square or round and the crooks and turns and whether of brick or iron, the former making for more resistance.

Factors in Draft

CONSIDERATION of adequate draft to cover these factors is no simple matter, but nevertheless should be squarely met.

Providing a good height of stack to produce a strong, vigorous draft involves some expense, but this can be offset by the use of fewer boilers at a less cost for a smaller building, as well as in the saving for foundations and piping.

It is becoming generally appreciated that there is also considerable economy in running with fewer boilers, because there is less expense for banking at night, as it costs no more to bank a highly developed boiler than for one running under or at normal rating. With intense heat the gases are more completely burned to carbon dioxide. Better circulation set up makes for better boiler efficiency. It is apparent that the economizer value is increased greatly in bringing to a conclusion the all around efficiency to be had from intensive firing by reducing the heat in the flue to the lowest point allowable to sustain draft. Good draft is necessary to the successful operation of any stoker, hence given the same co-operation with ordinary grates, less smoke will result if the fireman does not blanket the whole of his fire with green coal at a single operation.

Speaking of forcing, the use of any chimney is to force the fire, as every fire not left to smoulder or burn on the open ground is a forced fire. If you considered your boiler merely as a large kettle of some unknown size, whatever you could get out of it would be the capacity it was good for. Suppose you could get twice as much performance, or more than before, from any kettle, you would not consider you had caused any strain or injury, nor would you; hence the word "forcing" in the sense of working beyond or close to its safe usage as would be in mind by the use of the word applied similarly to an engine does not exist. So long as the limit of safe pressure is never exceeded, the safe output of steam is unlimited.

It has come about in practice that when a purchaser wishes to produce 1000 boiler hp. the builders generally furnish him 10,000 sq. ft. of heating surface or 10 sq. ft. per horsepower, as it is a safe measurement to use with a very ordinary draft. But whether the purchaser obtains 1000 hp. or twice that, out of the size he has bought, is purely a matter of supplying heat, and that is practically limited only by the draft strength to burn the requisite coal on the grates.

Fixing the Height

SO where a person is planning a new chimney, his course for determining the size should include consideration of the local situation, exposure to wind and its general direction. The distance of the furtherest boiler or boilers from the stack. Type of boilers and grates. Quality and depth of coal. The prime thing is a proper height, as it is this factor—adequately ascertained—that gives you the assurance of a provision for the essential force or pull to run your plant at a reduced expense for boilers, for their setting, piping and size of house, and with a better economy to boot. I wish you to note the distinction between draft pressure and draft capacity; the word "draft" is used too indiscriminately to either function and is unscientific as well as confusing.

Draft Per 100 Feet Height

CHIMNEYS give a draft pressure in direct proportion to their height, thus 200 ft. gives twice the pressure of 100 ft. and the pressure is the same for all chimneys having the same height whether the area is 1 or 50 sq. ft. in section; hence, if on a reasonable assumption of 450 deg. F. for your flue gases the draft is 0.6 in. of water with stack 100 ft. high when the outside air is 60 deg. then you will know that to obtain 0.9 in. 150 ft. height would be required regardless of any area, and for 1.2 in. the height must be 200 ft. and so on. Afterwards select the area to suit the volume from the expected amount of output.

This factor 0.6 in. per 100 ft. of height, the writer believes is a safe basis, as in the winter time the outside air is colder, making for a still better result, while in the summer it would be somewhat less by the outside air being hotter than the assumed 60 deg. yet the heating system is off so that the work will be usually somewhat less, and in addition you have 2 likely forces that will nearly always make the draft better than this given factor, namely, the assistance of the wind and more frequently hotter leaving gases.

The most helpful and practical data that I have come across was in a recent article by T. F. J. Maguire, which gave definite measures of draft resistance. (See Practical Reference Tables).

Loss of draft in boiler setting he measures as 0.3 in. for water-tube boilers, increasing to 0.4 of an in. with 50 per cent overload. Of course he intends this to be used with some judgment in application to the special boiler in mind, as to its construction and bafflings. The writer believes horizontal return Tubular boilers will be found to require the same allowance and the Manning and vertical types half of this or 0.15 in.

Loss of draft in breechings. Maguire allows 0.1 in. per 100 ft. of length to circular iron flues and 0.05 in. for each right angle turn. If square or rectangular shape, increase the above 25 per cent. For brick flues, increase the above 30 per cent. The writer would al-

(*From a paper read before the Franklin Institute.)

low for the stack travel the same as for the breechings.

Let us see how the application of such factors would apply to a concrete case where we assumed we wished to burn 25 lb. of soft coal under horizontal tubular boilers with 2 right angle turns in the breeching.

Furnace draft for 25 pounds soft coal....	0.2
*H. R. T. boiler.....	0.3
50 feet of steel breeching.....	0.05
Rectangular shape 25 per cent additional.	0.0125
Two right angles.....	0.1
Round brick chimney 150 feet.....	0.15
Brick surface 30 per cent additional.....	0.045
Total draft required.....	0.8575 in.

*Resistance increase with velocity, if therefore 25 pounds per square foot woud develop a considerable amount above rating, add a third to the boiler resistance. In the above it would therefore be 0.4 for the H. R. T. instead of 0.3 for its normal. This addition of increase will probably cover the flue resistance as well.

Or approximately 0.9 in. and we can get 0.6 in. of pressure per 100 ft. of height, then a 150-ft. stack should provide the total pressure needed. Notice that this stack height is independent of size or amount of horsepower output, except that more boilers would require allowance for longer flue travel which would be very slight.

I would like the opinion of others on this showing, because if general practice is shown to coincide, it will be of much value, and equally so if more reliable quantities can be established. I know at the outset that some will claim to have a 150-ft. chimney and cannot burn at this rate, and if so, the cause may be found due to excessive area absorbing the heat needed to produce the expected draft pressure or to some other accountable reason.

It may be pointed out that no allowance for economizer draft effect has been listed. But as the straight open-passage type of economizer has generally a greater free area than the flue, it can be reckoned on its length as for flue distance. Further, you must know that the top layers on the coal bed make for a greater proportional resistance, so an economizer saving 10 per cent of coal, would ease the fuel resistance to produce the same output of steam, thus practically offsetting any effect of its own resistance, while the owner is 10 per cent of coal in pocket with a proportionate draft pressure needed to accomplish the same output. This has proved universally true through a period of over half a century, so that the exceptions are now known to be due either to faulty installation, or fault in the design and size of economizer selected.

Until further tests have been made to determine the actual pressures required for the usual run of commercial qualities of coal and depths on grates, these figures may be treated with some caution, yet faulty as they may be, they will prove in the main quite trustworthy. Hence, I believe determining chimney height on a basis of such quantities, better than making a vague guess as is generally done.

For the Area

SIZE of the plant determines the area. The boiler horsepower of the output should not be considered in determining the height as we have just seen and as is mistakenly being done now, with rare exception, but it is the sole basis for determining area.

Some have a pet rule of making area proportional to the grate surface, regardless of the fact that if twice as much coal is burned in one case as in the other, it would call for twice the flue area, because of having double the amount of gas volume of the other. Others figure up all the tube area in their horizontal return tubulars or Mannings or measure up the outlets of the water-tubes.

In my own practice, I usually allow 20 sq. ft. for a single 1000 hp. boiler installation as being ample at normal running and also as allowing for the reasonable increased growth of plant and overload. For 2000 or more horsepower I reduce this area allowance about 10 per cent increasing the reduction on very large plants to perhaps 20 per cent, keeping 16 sq. ft. per 1000 hp. as well within a safe limit, where the plant becomes several thousand. For smaller plants, say 500 hp., for instance, I would allow 12 sq. ft. which is then more than 3 times the theoretical area on the moderate basis of a height of 100 ft.

If the chimney is above 10 ft. in height, the theoretical requirement is still less than 7 sq. ft. and as I never take less than 16 sq. ft. of area, which is more than double the theoretical for 100 ft. high, I consider that it is ample allowance for any overload, as well as safe, and I have never found any difficulty in practice by its application.

The smallest allowable area should give the best draft, as were we to increase 20 sq. ft. per 1000 hp. to 30 sq. ft., it would mean in a travel of 150 ft. distance up the stack, assuming this height, together with a flue length of 30 ft. to reach its port, that we have added 645 sq. ft. of surface to be warmed to the temperature of the gases with exposure to radiation loss, as well as increasing the air leaks caused by the chimney suction through flue seams and the porous bricks of this added surface. All of this excess surface put on by unneeded area is therefore making for a great detriment to the pulling force of the stack.

In actual practice the writer has found several stacks work close to their theoretical area capacity, as for instance at Lawrence, Mass., a chimney 128 ft. high above grates with flue area of 9 sq. ft. took care of 6 Manning boilers in a satisfactory manner, developing 780 hp. whereas the usual chimney tables recommend this size for approximately only 300 hp.

While I do not wish to deter those who have time and the disposition to figure a given chimney problem with accuracy, yet I believe the factors, 0.6 in. pressure per 100 ft. of height and the area factor at 20 sq. ft. per 1000 hp. for all heights, will be welcomed by many as safe quantities to use in selecting the 2 required dimensions of a new chimney.

If you must add something for "good luck" put it on the height, as you stand to lose less on this. The excess area will only come useful in a long distance future when the plant has grown to it, for the 20 sq. ft. basis for area is nearly 3 times the theoretical and provides sufficiently for all needs and reasonable increase.

To make my paper practical for those who have chimneys already built, I would say that yours is a case of studying your conditions to see what you can best get from them and suggest that you try running your plant on as few boilers as possible. I believe the result will prove decidedly advantageous. It may mean a little better attention to fires to prove it out, because if you are troubled with weak natural draft you must break up the fires oftener and study closely to obtain intelligent and more intensified firing.

Draft Troubles

IF you are troubled with poorer draft in winter than in summer, it is due to having the boiler room too tightly closed. If the firemen object to cold drafts from doors and windows, provide the air entrance from the top of the room.

Often the wind in certain directions, instead of assisting the draft makes for the contrary, which condition occurs when the wind is blowing in the direction towards the further boiler house door and this being kept open, the suction of air follows along out in the same direction, so that the end boilers nearest the door have difficulty in getting their supply of air through the grates.

Unutilized excess of draft pressure is bad and the boilers should be fired as near the limit of draft as possible so as to prevent such excess, but there will at times be a considerable surplus pull from the wind producing a greater draft at one time than another. That this excess draft is more common than otherwise is shown by the operation of the automatic regulation of dampers in the general run of plants, continually cutting off 25 to 50 per cent and more of the available draft throughout the entire day.

Of course as the plant is being run, the damper regulation makes for a great saving in preventing an undue excess of air through the grates, but the force should be put to work so far as possible to produce a more intense fire and by heavier coaling to run with fewer boilers.

Damper Control

IN this matter of draft regulation, it is much better to have a regulator that operates slowly than one so sensitive as to be opening and closing on a slight variation of pressure, thereby letting in an excess of air one minute, and then tightly closing, cutting off the air supply altogether.

If you have such a sensitive damper, it is not necessary to throw it out, just limit your range of damper opening, so that it does not shut tight or open to its fullest extent. The regulating damper should be as near the chimney as possible, and if it were placed at the top of the chimney, it would be better yet, as in times of closing, it would hold back that much more heat.

As it operates now in many plants, when the damper is closed at the port, the brick lining or core begins immediately to lose its stored up heat and the chimney cools off. Then when the demand for steam comes, instead of an active chimney agent, it takes a bit of a while for it to recover its lost heat and give vigorous draft; meanwhile, the plant is held back in getting the supply of steam demanded. The condition becomes worse where the regulation is applied to dampers in the boiler uptakes, as during the time of cut off the flues have cooled as well as the chimney.

A TREATISE on anhydrous ammonia is an interesting booklet giving the properties of this liquid and telling how to test it for boiling point, how to test the piping system for leaks, charging and removing the ammonia and other important information in regard to the refrigeration plant. It is put up in the form of a convenient vest-pocket book, with leaves of testing paper, perforated into strips for testing up ammonia leaks and pages for memorandum in regard to plant operation and data. This convenient leather-bound assistant to the refrigerating engineer may be had by writing to Armour & Co., Chicago, Ill.

DETERMINING THE PER CENT RELATIVE HUMIDITY, WEIGHT AND PRESSURE OF MOISTURE IN AIR

By J. ALBERT M. ROBINSON

IN order to readily determine the per cent relative humidity of air, the curves shown in the Practical Tables were calculated and plotted from Marks' and Davis' Steam Tables by means of Adjohn's equation. Each curve shows the variation of the per cent relative humidity for a constant difference between the wet and dry-bulb thermometers over a range of temperature of from 40 to 110 deg. F. of the dry-bulb thermometer.

The curves were computed on the basis of a 29.5 in. barometer, that being the average for Chicago over the last 5 yr. For a variation of barometric pressure of ½ in. either way from this pressure, the error is negligible for commercial work.

Assume that the thermometers of an hygrometer showed these temperatures: viz., dry-bulb, 82 deg. and wet bulb, 74.3 deg., the difference being 7.7 deg. Required the per cent relative humidity. At 82 deg. on the ordinate of the curves pass horizontally to the right (follow the dotted line), until a point is reached which would, by interpolation between curves 7 and 8, correspond to a difference of 7.7 deg. between wet- and dry-bulb thermometers. From the point thus obtained drop vertically downward to the abscissa, where the value of 70 per cent relative humidity is obtained.

Weight and Pressure of Moisture in Air

THE accompanying curves for determining the weight and pressure of moisture in air were also plotted from Marks' and Davis' Steam Tables. They were made with a view of minimizing the labor of solution of all problems that have to do with the weight and pressure of moisture in air, where the per cent relative humidity varies from 0 to 100.

Take the data of the preceding example; viz., temperature of air, 82 deg., and relative humidity, 70 per cent. Required the vapor tension, or pressure exerted by the vapor, and the weight of vapor, in 1,000 cu. ft. of moist air, or mixture of air and vapor.

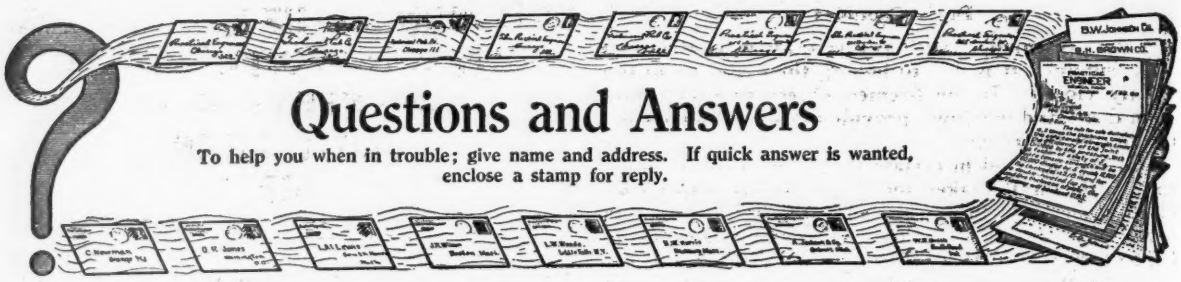
From the abscissa on the left rise vertically upward (follow dotted line) from 82 deg., until the "vapor tension" curve is reached. Then pass horizontally to the right until the line of 70 per cent relative humidity is obtained, whence drop down to the abscissa, where the value of the vapor tension is obtained. In this case, it is found to be 0.77 in. mercury.

To determine the weight of moisture, start in the same way from 82 deg., but this time pass upward along the dotted line to the "weight of vapor" curve, then horizontally to the right to the 70 per cent line, and down to the abscissa. The value obtained is 1.17 lb. of vapor in 1,000 cu. ft. of moist air, or 0.00117 lb. a cubic foot.

The significance of the vapor tension is this: suppose the pressure of the atmosphere, as shown by a barometer, is 29 64 in., mercury. Then the pressure of the dry air would be

29.64—0.77=28.87 mercury

The pressure of the dry air must be obtained before the gas law can be applied with accuracy.



Questions and Answers

To help you when in trouble; give name and address. If quick answer is wanted, enclose a stamp for reply.

THE CHIEF ENGINEER'S CATECHISM V

CAN you determine whether you are getting good combustion or not by the state of the fire-box?

2. Should comparison of boiler test for practical purposes be made from the cost of operation?

3. Would you recommend air or steam for atomizing oil for a furnace.

4. How is the heat value of natural gas stated, and what is the usual average value?

5. What is the relative economy of using gas in a gas engine and burning it under a boiler to make steam?

6. Do you prefer the horizontal or vertical type of fire-tube boiler, and why?

7. Why are safety and blowoff valves necessary on boilers?

8. Name the different types of stokers and explain how they operate.

9. Do you prefer iron, brick or concrete stacks, and why?

10. What is the approximate cubic feet of stack necessary for each U. S. boiler horsepower?

(The best set of answers to these question will be paid for at the regular rate, and the author of the second best set will receive a prize of $3. Answers will be published in November issue, and all answers should reach Practical Engineer not later than October 1.—Editor.)

Belt vs. Rope Drive

A CORRESPONDENT from India asks for information from readers, giving their practical experience on the following points: First, whether belt drive is superior to rope drive, or vice versa, and the arguments in favor of each. Second, which of these is cheaper to install and maintain?

Rust In Heating Coils

WHAT have Practical Engineer readers found to be the best method for removing soft red rust accumulations in steam radiators and heating coils? We wish to collect this rust in pockets where it can be removed and want to use something which will not cause the return water to foam and will not leave a mineral deposit in the heating lines. I. R.

Exciter Runs Hot

WE have a shunt-wound 6-pole 110 v. 800-ampere, General Electric vertical exciter, direct connected to an S. Morgan Smith vertical turbine water wheel with a Woodward governor running at 1150 r.p.m. It heats up considerably at a 300 ampere load of lights, motors and generator fields. Could this be due to the weather; the building is not very well ventilated?

R. A.

ANSWERS TO CHIEF ENGINEERS' CATECHISM III.

Coking vs. Non-coking Coals; Oil Fuel; Feed-water Purification and Handling

By Wm. A. Fischer

ON an average the coking coals have a higher evaporative value; they are high in carbon and produce more heat than non-coking coals. The non-coking coals are generally low grade and contain a large percentage of ash; their evaporative value is comparatively low as the heat producing value is considerably below that of coking coals.

In firing the coking coal it is good practice to employ the coking system, if the grate surface is large enough to permit it, otherwise the spreading system will be found the better. In firing noncoking coal it will be better to fire alternately or spread over the whole grate taking care to keep grates clean, and a good bed of fire must be kept at all times.

2. In my opinion anthracite coal is better adapted to hand firing than to stokers, because of its nature. It does not ignite easily, making it necessary for the fresh coal to come in contact with the hot bed of fuel at once which is almost impossible with stoker firing; also, in firing anthracite by hand the rate of evaporation can be increased considerably over firing it with stokers.

3. As a fuel for a boiler furnace, oil is far superior to coal, as with it there is a lower cost of handling of fuel, no dust or ashes to cover or fill the tubes, less manual labor for firemen and other advantages. But, if cost of fuel is considered, oil can not compete with bituminous coal, as in most parts of the country where oil is available its value for other purposes is so high that it is beyond consideration as a boiler fuel. There are parts of the country, though, where oil is cheap and good steam coals are scare and high in price, that oil is used to good advantage.

4. I prefer a horizontal return tubular boiler to any other type for the reason that it is easier handled and cleaned, its efficiency compares favorable with any other, and its durability is better and life longer than any other boiler that I know of.

5. Steam jets should never be used in a furnace, because being injurious to boiler plates the steam, being of a lower temperature than the furnace, cools it considerably; also, it mixes with the furnace gases and lowers their temperature thereby lowering the rate of evaporation.

6. Barometric conditions or altitudes above sea level affect stack draft considerably. It is known that air charged with vapor is lighter than when it lacks the vapor, in other words the more vapor any given quantity of air has in it, the less is its specific gravity. When barometric conditions are such that the air is damp or has lots of vapor in it, its specific gravity will

be low and the draft in a stack will not be as good as if the air were dry and of a higher specific gravity.

With altitude above sea level at higher altitudes the air is dry but is it lighter because of the less weight of air above, hence, the draft will not be as good.

7. All waters cannot be satisfactorily purified by cold water treatment for the various impurities in water may be either in suspension or solution, if the former the water can be puried by filtration before going into the heater and boiler but if the impurities in the water are in solution the substances must first be precipitated and then filtered and for rapid action that necessitates heating the water to or above boiling temperature before treating it. Cold treatment is possible, but takes a long time for precipitation.

8. The feed-water heaters most commonly in use are of the open type or the closed type. The advantages of the open heater are, that as a rule it contains a filtering chamber thereby taking some of the impurities out of the feed water, the exhaust mingles with the cold water in the heater and condenses making use of most of the exhaust steam for feeding the boiler. In the closed type of heater the exhaust steam does not come in contact with the feed water, eliminating the chance of getting oil into the boiler.

There is another type of feed-water heater called an economizer, which may be used to good advantage with a cold water filtering system. It makes use of the heat of the waste furnace gases to raise the temperature of the feed water. It is placed in the flue where the gases leaving the boiler, must travel to get to the chimney, the feed water being pumped through the economizer on its way to the boiler, and the hot gases passing around the tubes of the economizer, heating the water in some cases up to 300 deg. and effecting a marked saving of fuel.

9. Outlet from a feed-water heater should be high enough above the suction opening of a pump to allow the water to flow into the pumps at all times, the exact height depending upon conditions of a plant. If there is a back pressure in the heater while the plant is in operation, the outlet from heater should be high enough so that the weight of the water contained in the vertical section of the suction pipe will overcome that back pressure; this will avoid pump troubles when the supply of water happens to get too low in the heater and steam gets into suction pipe. As a general rule from 4 to 6 ft. is about the proper height for heater outlet above suction opening of pump.

10. I would use gate valves, as they have more nearly the area of the pipe than globe valves and the flow through the valve being in direct line with the pipe, reduces friction which allows the pump to work more easily.

By Fred G. Haney

ANTHRACITE coal contains a large percentage of carbon and a small percentage of hydrocarbons, and as the amount of hydrocarbons contained in the coal determines whether it is coking or noncoking, we place anthracite in the latter class.

Bituminous coal on the contrary contains less carbon and more hydrocarbons than anthracite and is a coking fuel.

Kind of coal	Percentage of ash	Theoretical B. t. u. per pound	Lb. of water evaporated per lb. (Theoretical)
Penn. anthracite..	3.49	14,200	14.70
Kentucky caking.	2.75	14,391	14.89
Kentucky cannel..	2	15,198	16.76

From the accompanying table it is seen that Kentucky caking and cannel, which are bituminous coal have more B.t.u. per lb., less ash, and more evaporative value than the best anthracite coal. Leaving out these 2 kinds of coal, anthracite will give better evaporative results than bituminous or semi-bituminous.

Anthracite coal should be fired by spreading a thin layer of coal over the fire, or by the side or alternate method, covering one side of the fire at one firing and leaving the other side bright; at the next firing the bright side is covered. The hydrocarbons given off by the fresh coal are burned by the hot gases from the incandescent coal. This method is superior to spreading because the entire furnace is not cooled off by the addition of fresh fuel.

Bituminous coal having more hydrocarbons (smoke producing quality) is fired by the coking method. The coal is piled on the grate just inside the door and allowed to coke from 15 to 30 min. During this time the hydrocarbons are driven off and burned by the heat from the fire. To accomplish this it is necessary that air be admitted above the grate through draft plates of furnace doors. The coke is then pushed backward over the fire and a new supply placed on the grate. The air admitted prevents the forming of carbon monoxide gas and smoke.

2. Anthracite is better adapted for hand firing; because it is a slow burning fuel, and the speed of the mechanical stoker would have to be very slow to insure the coal being burned before going past the dump grate. The speed of feed being so slow causes a thin fire; also the mechanical stoker cokes the coal, which makes the bituminous better adapted for this method.

3. Most decidedly oil is better than coal, for the following reasons: Fuel oil has from 16,000 to 20,000 B.t.u. per lb. One fireman can do the work of several. It is cleaner; no fires to bank or clean, nor ashes to handle. Boilers can give their maximum efficiencies and avoid smoke nuisance. One barrel oil (42 gallons) equals 336 lb. 3½ to 4 barrels equal one ton of coal, a saving of 45 per cent in weight, 75 per cent in space, and from 25 to 75 per cent in cost over coal, on the Pacific coast. Avoids opening the fire door, thus doing away with lowering of temperature of furnace and chilling tubes and boilers by admission of cold air. Good control of fire makes it possible to carry an even steam pressure throughout a run. The above reasons have been fully proved out here on the Pacific Coast, and oil has been adopted by all steam plants.

4. I prefer a horizontal water-tube boiler. One of the following would be acceptable: B. & W., Cahall, Stirling or Heine.

5. Steam jets are used to obtain greater draft and can be used directly in the furnace or in the ash pit. Tests made several years ago in the French Navy with jet above the coal, showed that the coal consumed per square foot of grate area could be doubled, but at the expense of fuel economy. With natural draft one pound of coal produced approximately 8 lb. of steam; with a steam jet less than 6¾ lb. of steam per pound of coal.

In placing the steam jet under the grates, the steam forms a sort of producer gas by mingling with the incandescent fuel and aids in the combustion of poor cheap fuel. The use of a steam jet helps to loosen clinkers from grate bars and furnace walls, but is wasteful as regards steam used by the jet; for this reason I would advocate using a fan blower either under ash pit, or, in stack.

6. Altitude will affect draft, since the pressure of the atmosphere decreases with every increase in alti-

tude, and since the pressure of the atmosphere at the same place is not constant. It is customary to express the pressure of the draft in inches of water. Now atmosphere pressure at sea level is 14.7 pounds per square inch, which pressure will support a column of water 34 ft. high, or 408 in. Therefore, 1 inch of water =14.7÷408=0.036 lb. per sq. in. or 5.2 lb. per sq. ft. Any change in this 14.7 lb. per sq. in. will make a change in stack draft.

8. Open and closed types of feed-water heaters are in common use. The open type is readily cleaned and easily repaired, but requires an oil extractor to prevent the oil from engines and pumps from mingling with the feed water, as in this type of heater the steam comes in direct contact with water; such an extractor is usually built into the heater. The heater must be placed on suction side of and above the feed water pump. The closed type of heater is more compact and requires less room; it can be placed on the delivery side of the pump and can also be used with injector, making it possible to pump cold water; it can also be installed above pump. It is not as accessible to repair, nor as easy to clean, as the open type of heater, but does not require an oil extractor, as the steam and water do not come in contact with each other.

9. The lowest point of outlet from heater should be at least 2 ft. above highest point of suction pipe, so that water will flow freely from heater to pump; otherwise the water will turn into vapor under the suction force and the pump will draw in either vapor alone or a mixture of vapor and water.

10. Straight-away gate valves are to be preferred on the feed-water piping as globe valves offer too much friction.

Some Answers From Wm. Chaddick.

Evaporative qualities of coking and noncoking coal seems to me to depend to a greater extent on the fireman and furnace than on the nature of the coal. I have known cases in which one fireman would make an excellent showing, while another would be a complete failure under the same circumstances. If the coal (the finer grades such as No. 5), does not coke, but packs close on the grate, it is very difficult to secure uniform air supply to all parts especially when using forced draft; holes will appear in different parts of the grate while the remainder is block.

Fine coal which forms a porous coke may be burned with good results by avoiding barring the fire but, if necessary, breaking down the coke with a light hoe. If the grates are stationary, use the clinker hook by sliding it along the grates to shake down the ashes; in the coarser grades the coking method of firing may be used. In plants where there is apt to be sudden calls for steam the free burning kind is preferable.

4. In small plants with small units up to 150 hp., I would prefer the return tubular boiler. When properly cared for it is as efficient as the water-tube and will not require so much labor in keeping clean which counts in those plants. But in large installations the water-tube boiler is better on account of the much larger units in which it may be safely built and its quicker steaming quality.

5. While steam jets are very often used to effect an intimate mixture of air and gases in the furnace they consume a large percentage of the steam generator and with a coal high in sulphur may form sulphuric acid and attack on the boiler shell.

Answers from C. B. Hudson.

1. Bituminous coal is considered to be coking and anthracite noncoking. A comparison of heating values of American coals of these two classes will give a good relative idea of their evaporative qualities. Average results of tests from 10 samples of bituminous coal show a heat value of 13,475 B.t.u. per pound, while the average from ten samples of anthracite show a heating value of 13,526 B.t.u. per pound, a difference of 51 B.t.u. per pound in favor of anthracite.

Quoting from an authority the result of a test as reported to the Engineers Club of Philadelphia shows an evaporation of 9.7 lb. of water from and at 212 deg. per lb. of anthracite coal and 10.17 lb. of water from and at 212 deg. per pound of bituminous coal, a difference of .44 lb. of water in favor of bituminous coal.

These results are slightly at variance with each other but do not show a marked difference in the evaporative qualities of the two fuels.

3. Oil cannot compete with bituminous coal as a fuel for boiler furnaces except in certain localities.

The principal reason is its cost.

A comparison of the heating values and other characteristic of the two fuels will show this to be true.

Fuel oil has a thermal value of 18,000 to 19,000 B.t.u. per pound against a value of 13,500 to 14,500 for bituminous coal.

A boiler and furnace efficiency of 82 to 85 per cent has been obtained with oil fuel against a maximum efficiency of 75 to 78 per cent for bituminous coal.

The greater efficiency of oil is due to the ease of control of oil burners by which a steady and great heat is maintained, the air supply is easily controlled, and just enough can be admitted to sustain combustion with a minimum excess of air, which passes up the stack as a heat loss. The waste gases from oil fuel leave practically no deposit on the tubes or shell to act as a heat insulator. Fuel oil occupies about 50 per cent less space than the same heat value of coal and is much more easily handled.

Against these qualities must be placed the cost of steam, or air used to atomize the oil, which amounts in the case of steam to 1.5 to 3 per cent of the steam generated by the boiler; increased insurance rates and other underwriters requirements due to its inflammable character. These attributes and its high first cost more than offset the increased efficiency of oil over bituminous coal except in localities where cheap fuel oil is abundant and coal is hard to procure.

7. Boiler feed water can be satisfactorily treated by the cold water process.

Suspended organic matter is removed, when cold, by filtration. Water containing sulphates and carbonates is chemically treated by means of a soda ash solution; this changes the sulphates to carbonates which are precipitated and sodium sulphate is held in solution. If an acid is present the carbonates remain in solution and lime is added to neutralize the acid which allows the carbonates to settle as a soft sludge which is blown from the settling tank or passed through a filter. The sodium sulphate remaining from this process passes into the boiler and is removed as a soft sludge by means of the blowoff pipe.

9. Inlet from the heater should be placed at such a height above the pump that the head of water in the suction pipe will overcome the tension of the valve springs, if there are any, the weight of the valves and friction of the ports and passages.

Three feet is as low head as would be consistent with good practice under all conditions and will vary from 3 to 5 ft. according to whether the pipe is straight or contains ells or globe valves.

THE TROUBLE MAN'S CONFESSION

HIS INDICATOR AND ITS USE

By Geo. H. Wallace

THE indicators which the Horsepower Engine Co., of Milville, furnished us fellows outside were like the old fashioned calling cards with mottoes on, which were popular (and unpopular) 20 years ago: "50 for 10 cents, no 2 alike." There were Crosby, Trill, New York, Buffalo, Robinson, Star, American and others, but the whole bunch were so abused that they were not worth $10. They simply gave the road man an opportunity to flash something new and different from the usual run of engine room apparatus on the engineer who does not study, talk elucidatingly to him about the expansion curve, the theoretical and diabolical incrustation of the admission line and point out with a nickel plated screw driver the exact point where the compression line steps over the tropic of Capricorn and coincides with the isothermal latitudinalization of the admission line.

Then while the engineer heaves in another wheelbarrow of coal, you affix another card to the drum, loop the loop over a bolt screwed into the sunny side of the crosshead pin, take another card and show him wherein the scientific denudinization of the approximator on this card does not coincide with the magnetic influence of the deodorizer on the antediluvian accumulator on the other card. He wipes his greasy mits on a piece of second-hand waste, cocks his hat over one eye, takes the card over to the only window, rubs some of the coal dust off it with his sleeve, looks earnestly at the card (upside down) for a brief moment and then exclaims: "Well, by George, it is so, ain't it. Y'c'n se it justus plain as pla-i-n c'n be. Gosh, I never knew that b'fore! Who-da thunk it!"

Then as soon as the old man comes around, the engineer gets him over in the corner behind the heater and N.N.E. of the oil barrel, and says: "Say, ol' man. See that m'hog'ny box that feller has over there," (pointing with his hand full of waste), "See it? Well, d'y' see that ere fonograph 'rangement on the side o' th' cvl'nder barrul? Well, that 'ere's a doodad that that feller says is the allfiredest do-funny y' ever saw. He ties it onto the ingine with a string, puts the fly leaf out o' a catalog on a pepper box riggin', and by cracky! he makes the pooties picktcher o' the side view o' a hand sled that y' ever saw! He does, by gum!"

Then the super thrusts his hands into his pockets, spits on the floor and says, "T'ell y'say!"

"Yessir, that's right, all right, all right. Say boss, that 'ere's the smartest feller ever bin araound these 'ere parts. Betcher that feller gradgerated fr'm Harvard er Yale er Budweiser Collidge. Betcher 'e did. He's eddicated, that 'ere feller it. Say, boss, 'e's a bang up smart cuss."

Thus injected full of the engineer's enthusiasm, the boss goes over to inspect the antiquated indicator, while the engineer goes out to the boiler room, hits a barrel one fell blow with the scoop, throws the pieces into a fast cooling firebox and then looks up to see if the steam is beginning to rise already.

The boss looks at the indicator critically and inquiries: "Mr. Roadman, our engineer sez that this is a intelligent contraption. Wot's it fur?"

"Oh, that's only an indicator."

"But wat's it indicate? The wind er the weather? 'Taint no th'mometer be it?"

"No, it's to indicate the horsepower of an engine, (within a mile), so you can always tell just where you stand."

Meanwhile the engineer comes in from the boiler room, wipes his perspiring face with the same waste with which he wiped the cylinder oil off the coffee pot, stands up beside the boss with a "didn't-I-tell-you-so" attitude and inquiries:

"Watcher think 'v it, boss?"

"M-m-m-m, caynt tell much erbout it till I see 'er run once. Say, Mr. Roadman, wind the darn thing up again till I see 'er spin."

The road man "winds it up again," takes the card off the drum deftly and, holding it up before the boss, by the aid of a broken hacksaw blade explains the diagram as follows:

"Now, right here the vaporization of the equilateral overbalances the general tendencies of the valvulinears to obsquatulate the recedement of the pistonary. This produces a sympathetic vibration of the laminations in the octogenerian diadem and causes the elementary lever to vibrate intermittently against the exterior of the junk valve and this in turn produces the proper consistency of the ingredients to produce combustion in the planimeter. When the barometer rises to the altitude of 119 centimeters, it overpowers any tendency on the part of the armature to induce the eccentric to articulate, and pulls the doogan pin out of the vulcanizer, making the record as here indicated. By this time the crankpin has traveled from Beersheba to Caanan and the whole process is repeated backwards, producing the illustration now before you, and there you are."

"Gee Whittaker! Yeau don't say! Say, Hennery," (to the engineer), "you be right after all. I thought y' were ject a-stringin' me, but this 'ere engine man, he 'splained it all out t' me 'nd it's jest as clear as clear c'n be. Say, Mr. Roadman," (to the latter individual), "you've got an all-fired lot jammed away in that 'ere cocoa of vourn. Y' must be a perfesser, at least. Wot collidge didger gradgerate from, young man?"

"Well, Mr. Superintendent, I don't like to talk about those things much. It gets on my nerves. I don't know much at all, but if you will keep it under vour hat I don't mind telling you that I graduated from the largest school in the world—the one that has turned out more graduates than any other school in existence."

"Well ——— ——— ——— ! Whatcher know 'bout that, Hennery!"

"Didn't I tell y' he was a p'fesser?"

"What school was that, Mr. Roadman?"

"The School of Experience."

And that's the only reason the road men carry the bum old indicators that they often have along.

Take a small quantity of oil, and place in a vessel of boiling water, say about an ounce of oil to six times its volume of water; also steep in the water a piece of red litmus paper. After the whole has soaked for a while if the litmus paper remains red, the oil contains acid. If the paper turns to full blue the oil is alkali. If the color of the paper changes slowly to a light blue, the oil is neutral.

PLANT RECORDS AND COST

By J. George Ould

IN ANSWER TO A REQUEST for data of cost of coal, oil, and supplies, for a power plant in actual operation, the following figures are given as for working conditions of the Polhemus Memorial Clinic, Brooklyn, N. Y.

So that one plant and the cost of its operation may be intelligently compared with that of another, one should have some idea of the design of the plant, the use to which it is put, and the conditions under which it is run.

Conditions of Plant Operation

THIS plant was designed in 1896, completed at the end of 1897 and has been in operation since January 1898. It is in a building which is used as a medical college, and out patient department of a hospital, and is used in the daytime only; even in winter time, except in case of a severe blizzard, the fires are banked over night.

The first year of operation, steam was on in the winter for 24 hr., but circumstances arose which made it wise to bank the fires. The building, of steel, fireproof construction, is very heavy and retains its heat

ARTICLE OIL CYLINDER PRICE 40¢ GAL.
1910-11

DATE	QUANTITY RECD.	GIVEN OUT	ON HAND	DATE	FOR	COST
OCT. 1			10			
" 6	100		110			
" "		5	105		DY. TANK	
" 13		5	100		PM. "	

FIG. 1. SAMPLE OF RECORD CARD FOR SUPPLIES

all through the night, the morning temperature when steam is turned on, averaging about 60 deg. F.

The college year is from Oct. 1 to June 1, and between those months the plant runs with its highest load. The Dispensary or Out-Patient Department runs all the year and, in the afternoons, needs electricity, compressed air, etc. It is also necessary to have steam all the year for the refrigerator, which cools the anatomical storage room.

Equipment

THE main feature of the plant is the heating and ventilating. Most of the power being used for this purpose. The building is ventilated by means of plenum and suction fans.

In the lower engine room are 2 Sturtevant plenum wheels, each 84 in. diameter, with floats 48 in. wide. The casings are about 11 ft. in diameter. These are coupled together and are driven by a belt from an engine having a cylinder 10 by 16 in.

On the top floor there is a plenum wheel 54 in. diameter, driven by a 7½-hp. electric motor. There are 2 suction wheels, one 60 in. the other 84 in. diameter, one driven by a 20-hp. the other by a 25-hp. electric motor.

Heating is distinct from the ventilation and is for the most part direct radiation. All coils are under thermostatic control.

To supply the motors with current and for lighting and other power, 3 50-kw. direct-current, 125-volt electric generators were furnished, direct connected to high-speed, simple engines. About 3 yr. ago we took out one of the 50-kw. machines and put a 10-kw. in its place, for summer work, the load at that time being very light. It was originally intended to use the building or a portion of it until 10 p. m., so power was put in sufficient to take care of all lights.

The elevator system is hydraulic, 1 passenger, and 3 freight elevators. The passenger elevator runs 9 mo. of the year. The pumps for the elvators are compound duplex.

There is a 10-ton absorption refrigeratory machine, for cold storage work; various pumps and 2 small air compressors; 2 B. & W. boilers, each with 35 sq. ft. of grate surface.

Special Provisions

A GOOD deal of attention is paid to appearance of the plant, most of the pumps being bagged with Russian iron with spun brass or copper heads and trimmings; oil piping, engine drains and such small pipe, are brass, nickel plated.

Engines are oiled from a control supply, which is brought up to the engines by compressed air. The oil is cleaned and used over and over, and is run as fast on the bearings as they will take it. Cylinder oil is also taken from central reservoirs and piped to the engines and pumps.

Coal Handling

MOST of the supplies are bought once a year. Coal is contracted for from April 1 of one year to April 1 of the next. Coal, No. 1 Buckwheat, is stored in a vault under one of the sidewalks through 10 coal holes in the roof of the vault, and on the edge of the sidewalk so that coal may be dumped into the vaults, without trimming, so saving that cost. We can hold about 200 tons. A track suspended from the ceiling runs the lengths of the bunker, and there is a roller bearing 4-wheeled trolley on the track to which a 500-lb tipping bucket is attached. A part of the track is a portion of a scale, the beam being at a convenient place for the fireman to weigh all the coal as it passes over the scale. The track goes up to the boiler so that coal can be dumped close to the fires.

A similar track is used to take the ashes away to the ash elevator. The ash buckets are 18 in. diameter by 36 in. deep. They are counted. A number have been weighed when full of dry ashes and the weights averaged. The ashes usually being wet they cannot be weighed.

Records

THE engineer keeps a record of his stock of supplies on a set of cards, of which Fig. 1 is a sample and explains itself.

Each article has its own card, or as many as may be necessary. For instance, we use about 30 different sizes and kinds of packing. There will be a card for the steam piston rod of a pump, one for the water piston rod, one for piston packing and so on. The use of these cards is that they are a perpetual stock test, from which to order and keep the stock from being too much or too little.

It also shows the cost. Say in the case of packing, if 2 rods of the same size are being used about the same amount show unequal use of packing, attention is drawn to the rod which is using too much.

Each month a statement is made of cost, the amounts for oil, packing, waste and general supplies being taken from these cards.

Feed water is passed through a hot-water meter, the reading being taken every day. It has a bypass arranged so that it can be calibrated by means of scales. This may not be exact, but is a most excellent check on our work and I do not think the error is very great.

Steam Uses

EXHAUST steam is used for heating at from 1 to 2 lb. back pressure. In winter time we use all our exhaust, and in very cold weather have to use live steam as well, so that electricity becomes a byproduct to us, the engines acting as reducing valves.

Exhaust steam from the air compressor is used as the supply for the generator of the refrigerator, its returns being used with the feed water. We have a closed heater which heats the feed to 210 or 212 deg.

1909	COAL	OIL	PACKING	WASTE	GEN. SUPPLIES
OCT.	166.37	7.25	3.78	1.25	7.58
NOV.	190.67	2.11	8.91	1.30	9.65
DEC.	223.52	2.50	3.96	1.02	6.78
JAN.	258.27	3.27	2.30	0.70	8.07
FEB.	236.94	2.23	3.76	0.73	6.03
MARCH	216.03	6.06	3.67	0.88	7.49
APRIL	181.84	5.07	1.89	1.19	5.91
MAY	174.41	2.30	1.17	1.44	5.20
JUNE	53.92	3.87	3.85	0.98	11.38
JULY	50.40	0.56	4.16	0.86	7.28
AUG.	56.70	1.34	3.22	0.98	9.92
SEPT.	57.33	1.40	12.96	0.66	4.38
1910	1866.40	37.96	53.63	11.99	89.67

FIG. 2. COSTS BY MONTHS, OCT. 1909, TO SEPT. 1910

the heater being of ample size for the water to pass slowly through it.

In the cold weather steam is turned on about 5 a. m., for heating; at 7 a. m. the machinery is started and runs until 5:30 p. m. Sundays in winter steam is on 8 hr. for heating.

During the summer, the refrigerator runs from 8 a. m. to 5 p. m., the 10-kw. machine in the afternoons, and all day if lights are needed. The ventilating apparatus is shutdown, and elevators used but little.

Daily Log

A DAILY log is kept of coal used, amount of ash, supplies used, time of starting and stopping engines, motors, etc., water, gas meter and ammeter readings. The method used for this purpose in this plant was described and illustrated in Practical Engineer June 1908.

The fiscal year commences Oct. 1 and ends Sept. 30.

The figures given are for material used between Oct. 1, 1909, and Sept. 30, 1910, the last full year.

The building is 8 stories high, though taller than that number of stories would be in an office building. The top floor for instance, to the skylights being 28 ft.

The crew consists of an engineer in charge, an assistant, a helper whose principal business is to keep the place clean, and one fireman.

The general superintendent is also chief engineer of this plant.

In the summer months, such changes as may be necessary in the machinery are made, and the plant is overhauled and thoroughly gone over.

Records of Coal, Oil, Etc.

THE coal used was 592.51 net tons @ $3.15 per ton. Ash 96.00 net tons.

The water passed through feed-water meter was 8,681,390 lb., the meter being calibrated at a temperature of 212 deg. F. In summer time the feed water runs to about 200 deg., except for the first hour in the morning, when it will be as low as 150 deg. No correction is made for this. The number of days under steam including heating for Sundays in winter, was 326.5.

We do not pay for the cartage of our ashes.

The coal used includes that for banking and steam raising.

I have not given the cost of repairs, etc., since the question asked was the cost of coal, oil, and supplies.

A YOUNG MACHINIST MISSING

INFORMATION is wanted as to Mr. Albert Bettesworth, of 418 Summerville Ave., Philadelphia, Pa., who has been missing since June 2nd., without any word being received by his cousin, Mr. Herbert Norton, with whom he made his home, or by his parents in Liverpool, England.

Bettesworth was employed in the Armor shop of the Midvale Steel Works, in Philadelphia, but left the

city on account of the irregularity of the work there. The only explanation left by him was a note to his cousin stating that he would write as soon as he had obtained work elsewhere. He is 21 years old, 5 ft. 7 in. in height, and weighs about 135. His complexion is fair, and he has brown eyes and light wavy brown hair. At the time he was last seen, he wore a dark suit with a small stripe. His silver watch had his name engraved on the works.

Anybody learning anything of his whereabouts, or of anyone answering to this description meeting with an accident during June or July, is requested to communicate with Mr. Norton at the above address. It is of course possible that he is working under another name, although it is likely that in seeking employment he would mention the Wheeling Mold & Foundry Co., or the Harrison Safety Boiler Works of Philadelphia, for whom he had also worked.

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ADVANTAGE FROM ARTIFICIAL DRAFT

Argument has run riot as to whether natural chimney draft or artificial is to be preferred for operating a steam plant, and given a certain limit of efficiency there is chance for careful consideration, but there are certain advantages to be secured by the use of artificial draft, which, considering the modern tendency regarding power plant practice, are distinctly its own. We have heard much in the last few years regarding the possibility of getting greater boiler capacity than has been common practice by forcing the fires and by arranging the heating surface to give rapid circulation of the water in the boiler. We are now hearing that by this greater "forcing" which is after all not an overloading of the boiler, but simply utilizing its possibilities to the fullest extent, we can cut down the cost of investment and upkeep as well as using a smaller building and reducing overhead charges all along the line.

We are coming to recognize that the limit of boiler capacity has been not the ability of the metal to transfer the heat from the hot gases to the water, but the ability of the furnace to burn the coal properly. One writer, C. D. Roehl, before the American Street and Interurban Railway Engineering Association, advocates an increase of evaporation of 100 to 150 per cent in boiler practice which would give us about 5 sq. ft. of heating surface per boiler horsepower and states that "there is little reason to doubt that the best which has at the present been accomplished will, in a few years, become standard practice."

Another reason for using mechanical draft and an advantage which inheres in the greater capacity operation which is now advocated is that with the thicker fire carried there is a better chance to mix the air and the gases, and also there is less likelihood of burning holes in the fire, so that a more uniform combustion all over the grate is secured.

As to cost of operation, Henry G. Brinckerhoff, speaking before the Franklin Institute, states that 1 per cent of the boiler horsepower output will meet the demand even for concentrated operation, and that when the steam from the fan engines is turned to heating feed water the cost of operating the mechanical draft system may be ignored. The addition of mechanical draft to an overloaded plant is frequently the solution of the problem of getting greater capacity with a growing load, and where the high rate operation produces too high a stack temperature, the addition of an economizer brings down the loss of heat from that source.

Speaking of the addition of a fan to an overloaded plant, Mr. Brinckerhoff says that it is common policy to use this regardless of addition to the plant, but the only situations where it will be of benefit are when stack is too short to produce the necessary draft for burning what coal the grate can well take care of and the boiler will absorb.

In order to get advantage from the artificial draft

there must be ample area through flues and chimneys to take care of the gases formed. If this be not the case a fierce blast is required to overcome the resistance and force the gases to atmosphere, thus making it a source of danger to the fireman every time the doors are opened for coaling, and also injuring the settings and the boiler front.

It is, therefore, necessary when using a forced draft with a closed ashpit to have the draft at the other end of the boiler at any rate sufficient to carry the gases away from the furnace, the forced draft serving only to send the air through the fuel bed. When there is trouble the only remedy is to provide greater area in the passages through the boiler and in the stack, and this might be done by adding a short stack to take care of the excess gases, or as Mr. Brinckerhoff suggests in the case of a water-tube boiler, it is sometimes possible to remove all the baffles, thus cutting down the friction of the gases in passing through the boiler.

RECENT TURBINE ACDIDENT

TWO men killed, and two injured was the human toll exacted at Riverton, Ill., recently, as a result of an accident in the power house of the Illinois Traction Company.

The turbine was of the Curtis type, 4-stage, 2000 kw. capacity, and had been out of commission for the first time since its installation some years previous, to allow repairs on the governor, and the installation of new bearings.

Late in the afternoon the turbine was warmed up and started with the throttle partly open. It appears that the turbine had run for about 10 minutes in this condition with a speed about 400 r.p.m. when the 3-stage rotor failed, carrying with it the third stage-diaphragm, its centrifugal force tearing away parts of the outer casing and sending flying fragments of metal in various directions. One of the smaller pieces, after striking the men, continued on its way, knocking over a 50-kw. motor-generator set, demolishing a 100-kw. transformer and ripping out oil, steam, and water lines. Other pieces seriously damaged other units.

The exact cause has not yet been determined upon, but from reports 3 conditions favorable for such an accident, may have existed.

Vibration due to critical speed, and exaggerated by any balancing in the new bearings, may have caused the rotor, literally, to shake itself to pieces, resulting in the failure of the third stage wheels. But it appears that the repairs were not of a character to affect the balance, and as the turbine had been in constant and excellent operation for several years, there is grave doubt about this theory. Besides the other apparatus in operation at the time, a 1000-kw. turbine situated about 8 ft. from the one damaged, was running at full speed. It is quite probable that in repairing the governor, it had become slightly defective, allowing the turbine to run over its normal speed, and the pitch or tone, which would have foretold the excessive speed was overcome in the noise from the other turbine and apparatus.

After the accident, upon investigation, the inner extremity of the fourth-stage diaphragm was seen to be crushed outward, and a heavy scoring or grove, on the side toward the 3-stage wheel, indicated that a nut, wrench, or some foreign article had been left in the turbine when opened for inspection. Any such thing wedged between the diaphragm and wheel would quickly have gouged out and cut the rotor, and the rotor, in its weakened condition, was torn away from the shaft, by the centrifugal force. What is left of the third-stage diaphragm, shows no marks of any kind, indicating that pressure had been suddenly brought against it from the third-stage side, and bearing out the probability that something had been left in the machine.

GEORGE FARRINGTON HUGHSON

IT is always sad to record the passing on of one who has been of great help to his fellow men and who has accomplished much work for the benefit of the community, but when such record must be made it is comforting to be able to add that he leaves a record for the strictest integrity, for absolute fairness and squareness in all business dealings, and that many friends and no enemies are to be found among those who know him.

Mr. Hughson was in his 51st year, having been born in St. Paul, Minn., on March 25, 1860. Of his early life there is no detail available, but his coming to Chicago was 23 years ago, at which time he became vice-president and sales manager of the John Davis Co., which was engaged in the manufacture and sale of steam specialties. This was in the early days of

the steam specialty trade, and the line was small, and, according to present standards, inadequate.

Mr. Hughson devoted his entire thought and interest to the developing of the line of Eclipse specilties, most of which were his own invention, either entirely or as to important details. After 21 years service with the John Davis Co., Mr. Hughson formed the Hughson Steam Specialty Co., which took over the Eclipse patents, patterns and good will, and became president of the new company, in which capacity he served until the time of his death. For some time Mr. Hughson has been ill with Brights disease, but until 2 weeks before his death he was not confined to his bed. He died July 19, at his home on Woodlawn Ave., Chicago.

Mr. Hughson was active not only in business affairs, but in athletic, and in the interests of the world about him. He was a member of the South Shore Country Club, the Illinois Athletic Club, the Glenoak Country Club, and the Western Golf Association. He was particularly interested in the latter game, and was prominent in many amateur tournaments, winning several medals by his careful and accurate play.

He leaves a wife, and a son, Harry, who takes his place in the company and is now its president.

REDUCTION IN OPERATING EXPENSES

ISOLATED plant engineers have a good many corners to watch in keeping down operating expenses. One of these, which, though very important, is sometimes not given its due amount of consideration, is the water supply system.

It is interesting to note how Asa P. Hyde, chief engineer of the Security Mutual Insurance Building, Binghamton, New York, made a big saving in his running expenses by substituting a high efficiency triplex power pump system for the steam pump system which had formerly been used to supply water for the hydraulic elevators in the building.

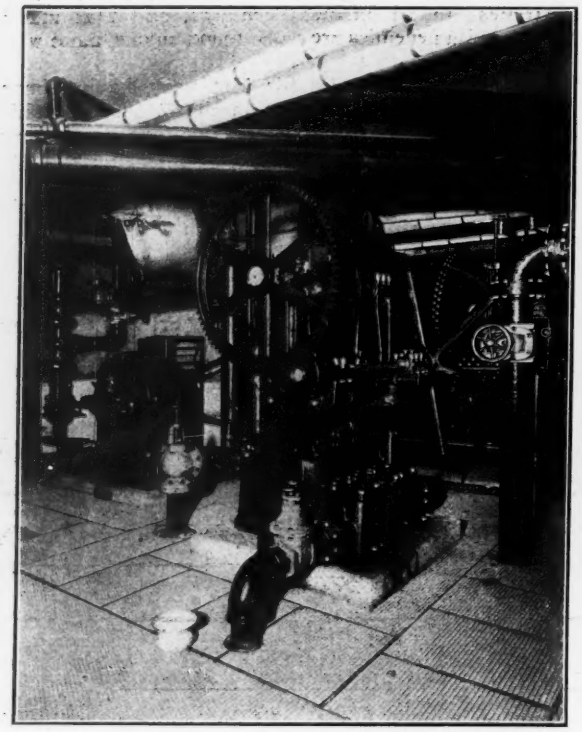


FIG. 1. ARRANGEMENT OF MOTOR AND TRIPLEX PUMP

This equipment consists of 2 8 by 10 in. triplex pumps manufactured by the Goulds Manufacturing Co., each of which is driven by a 40-hp. motor, operating against a pressure of 170 lb. per square inch. In addition, the old steam pump equipment was left in the building as a reserve equipment, the large saving shown by the motor driven pumps making it inadvisable to use the steam pump regularly.

The tests made by Mr. Hyde on the steam pump and new triplex power pumps under the same conditions of service show that the new equipment has given him a saving of over 2290 lb. of coal a day.

When the tests were made, data were taken from a 2 days' run with the steam pump, and identical tests were made with the motor driven pumps. The number of trips made per day with the electrical driven and the steam pumps for the 2 days was practically the same, 882 trips a day were made when the steam pumps were on test and 850 trips when the motor driven pumps were on test.

In addition to the great coal saving, Mr. Hyde states that the new pumps also show a big saving in operating and maintenance expense as the electrically driven pumps require practically no attention. The motors are controlled automatically and start or stop without attention whenever the pressure rises or falls below or above normal, and the only attention the pumps require is an occasional oiling.

WHY IS IT DURABLA?

THE secret of the Durabla quality standing for durability is the mixture in the compound. This is metallic in nature, producing a hard glass, which at the same time, has the metallic property expansion and contraction without breaking.

Because of its metallic nature it is exceptionally elastic; and it is eaten less by soda on account of this

FIG. 2. END VIEW OF TRIPLEX PUMP IN ISOLATE PLANT

hard quality, therefore remains clear under difficult conditions; also will withstand changes of temperature.

It will thus be seen that Durabla quality glass is by the process of manufacture made a product having iron toughness and great elasticity.

It is for sale by R. G. Von Kokeritz & Co., of 114 Liberty St., New York City.

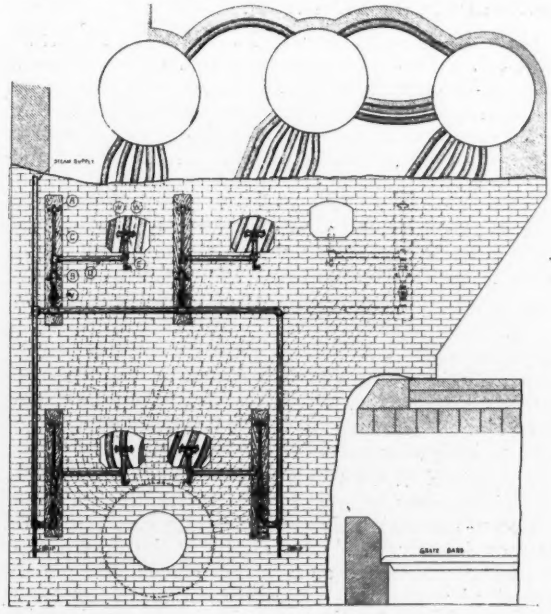
NEW DIAMOND SOOT BLOWER FOR STIRLING BOILERS

IT is just as important in the case of water-tube boilers that the heating surfaces be kept free from soot and dust as it is in the case of return tubulars; particularly where a boiler has high steaming capacity it is desirable that it be kept in the best possible condition, hence, the design of a new type of soot blower for Stirling boilers is noteworthy.

From the illustration it will be seen that this new Diamond blower has 4 units and, if desired by the cus-

tomery, a fifth can be supplied, its function being to blow the soot off the first baffle. All parts of the blower have been designed along the lines of simplicity, effectiveness and permanence. Each unit is equipped with 2 nozzles and swings in and out of the cleaning doors whenever desired.

One unit is operated at a time, and when not in use all units are entirely outside the boiler frame so that no



BOILER EQUIPPED WITH DIAMOND SOOT BLOWER

heat can affect them. Evidently this construction tends to give long life and satisfactory service. Each unit is provided with a pet cock for draining the condensation before starting to operate. The new design is made by the Diamond Power Specialty Co., of Detroit, Mich.

TRIPLE SHEET PACKING

THIS name is adopted for a new sheet packing, which is made up of 3 sheets, a red rubber compound on each side, a black hard rubber sheet between. It has been designed especially to be strong and tough to make a perfectly tight and permanent joint, no matter how rough the flange surfaces may be, to be unaffected by expansion and contraction of piping, to avoid crawling in the joints, and to avoid hardening, rotting, melting, burning or blowing out.

The manufacturer, the Gutta Percha & Rubber Mfg. Co., of New York City, has designed this packing for use against steam, hot or cold water, air, gas, ammonia, in fact for durability under any service. It is claimed that the peculiar construction has resulted in a new type of packing.

NEWS NOTES

THE ALBERGER CONDENSER CO., and The Alberger Pump Co., have opened a branch office at 97½ Peachtree St., Atlanta, Ga., which will be in charge of R. S. McMichael. Also the Pacific branch office of these companies at 503 Market St., San Francisco, is now in charge of the C. F. Braun & Co., Inc., of which Carl F. Braun is president, Geo. C. Singletary, vice president, and Emory S. Singletary, secretary, this corporation succeeding the one formerly known as Braun, Williams & Russell.

THE FIRST ANNUAL MEETING of the Institute of Operating Engineers will be held in New York, September 1-3, at 29 W. 39th St., the hotel headquarters being at Hotel Navarre, 38th and 7th Aves., and Hotel Woodstock, 127 W 43rd St. Registration will be from 9 to 10 a. m., on September 1, followed by the first meeting, with addresses on The Operating Engineer's Future, by F. R. Low, The Engineer's Place in the Community, by D. B. Heilman, The Employer and the Engineer, by A. C. Dougall. In the afternoon a meeting will be held at 2 p. m., at which technical papers will be presented on Temperature Changes and Heat Transmission, by Vernon L. Rupp; Boiler Room Analysis of Coal, by J. P. Fleming; Cooling Towers v. Steam Pumps, by Henry W. Geare. In the evening a meeting will be held at 8:15 at which an address will be delivered by Prof. Wm. D. Ennis, of the Polytechnic Institute, Brooklyn, on teaching Operating Engineer, by Jas. A. Pratt, of the Williamson Trade School, and by Frederick H. Sykes of Columbia University.

The morning session of Saturday will be devoted to business of the meeting and in the afternoon professional papers will be presented on Engine Lubrication, by R. D. Tomlinson, Reduction of Lubricating Costs in Smelter Power Plants, by Geo. L. Failes, Removing Emulsified Oil from Condensed Water, by Darrell Sage. Sunday, the 3rd, will be devoted to trips about the city, which will be provided for by the local committee to meet the wishes of those in attendance.

AN IMPORTANT CHANGE in the management of the Keystone Electrical Instrument Co., of Philadelphia, has just taken place, Richard P. Brown becoming president of the company, Mr. J. Franklin Stevens resigning, but Mr. Stevens' advice and interest remaining with the company. Mr. J. W. W. Cornman, the former secretary, will continue in his capacity.

Richard P. Brown has for a number of years been president of the Brown Instrument Co. of Philadelphia, established in 1860, the oldest concern in the United States manufacturing pyrometers, and this company has naturally had wide experience in the design and manufacture of scientific instruments.

The voltmeters and ammeters manufactured by the Keystone Electrical Instrument Co. have always been designed in a manner particularly to meet general industrial service, and under the suggestions of Mr. Brown, slight changes in construction have been made, which will recommend them to engineers who will recognize these improvements. Their sales will also doubtless increase through the live organization of the Brown Instrument Co.

By this arrangement, the Brown Instrument Co. and the Keystone Electrical Instrument Co. will manufacture pyrometers, thermometers, speed indicators, draft gages, recording gages, voltmeters and ammeters. In fact, they are now in a position to manufacture or repair practically any type of instrument.

In addition to the works and office at 9th St. and Montgomery Ave., Philadelphia, an office will also be maintained, for the present, at 311 Walnut Street. Branch offices of the Brown Instrument Co. at Pittsburg and Chicago will, of course, be continued, and will now also handle Keystone instruments.

ASHLEY P. PECK, for 6 years identified with Allis-Chalmers Co., as sales engineer, connected with its New York office, has recently associated himself with the Terry Steam Turbine Co., as district sales manager for the Middle West, with offices at 814 Peoples Gas Bldg., Chicago, Ill. Prior to 1902, Mr. Peck was actively connected with the machinery sales field of Chicago, and

since that date, for 3 years, was manager of the Milwaukee district sales office of the National Electric Co., going from Milwaukee to Allis-Chalmers Co., at New York in 1905.

M. M. SANDERSON, of the Warren Lubricant Co., with associates, has purchased the interests formerly held in that company by Frank L. Young and Mr. Kimball. As scientific makers of solidified lubricants they will continue the business at 22-24 Mourice Street, Buffalo, N. Y. The following are the new officers: M. M. Sanderson, president and general manager; A. J. Squier, vice-president and secretary; C. C. Bradley, treasurer. Mr. Sanderson will continue to give his personal attention to the affairs of the company.

MESSRS. C. M. WHEATON, C. W. Tylee, and Staples, have bought the interests of Mr. Parmeter in the Federal Metallic Packing Co. Mr. Tylee will take Mr. Parmenter's place as treasurer. The business will be conducted in the same place and in the same way as heretofore. This company is giving special attention just now to its Federalite pump valves, which are claimed to have great advantages over rubber valves in durability and cost.

ALOZO PAWLING, president and treasurer of the Pawling & Harnischfeger Co., Milwaukee, and for many years a prominent figure in the machinery field, has disposed of his interests in the company and retired from business life. Mr. Pawling's withdrawal from the business world will mean a distinct loss to the many friends he has made during his long and successful career as one of the foremost manufacturers of the middle west. In December, 1884, Mr. Pawling, together with Henry Harnischfeger, founded the Pawling & Harnischfeger Co., under the firm name of Pawling & Harnischfeger. From a small beginning the concern has grown to huge proportions. Mr. Harnischfeger becomes president and treasurer of the company; W. H. Hassenplug, vice-president; F. P. Breck, second vice-president, and S. H. Squier, secretary. There will be no changes in the policy of the company or its organization other than given above.

CATALOG NOTES

THE BURY COMPRESSOR CO., Erie, Pa., issues a circular describing its automatic pneumatic force feed oiling system with which it is equipping its power-driven, motor-driven and steam driven compressors. This system enables the machine to run at practically ⅓ higher speed, as it insures a sure and copious supply of oil flooding the main bearings at all times. The oil is used over and over again and is strained so that any dirt that might accumulate in the enclosed frame is removed from it before being pumped from the oil well tank. This pumping is by a small plunger pump located in the tank and to which the oil flows by gravity from the bottom of the crank pan, and from which it is forced by the pump operated by air pressure at each stroke of the piston. The air is transmitted by a small brass tube leading from the air cylinder to and actuating the small plunger pump. In the oil well tank the oil is passed through water and clarified, cooled, filtered and strained, and then is forced to the reservoir above and in the center of the machine; from there it is distributed through a suitable connection —under pressure when the compressor is in operation, and by gravity when the compressor is unloaded—and is delivered to the various adjustable sight feeds at the proper points to be lubricated.

In steam machines where there is condensation it is arranged to separate and siphon off the water from the oil so that oil only is returned for lubrication. This circular will be gladly sent to anyone upon request.

PLASTIC FIRE BRICK, for building up in position any shape required for an arch or furnace, is found of great convenience by many users, and in a booklet just issued by the Betson Plastic Fire Brick Co., of Rome, N. Y., the opinion of users is given, also an explanation of how the Betson Plastic brick is used to advantage in the boiler room.

THE JONES STOKER IN SMALL PLANTS, which is an explanation of how this device helps in small plant economies, is attractive and convincing reading, showing what the Jones Stoker has accomplished in plants where ordinarily mechanical stoking is considered out of the question. The book is handsome in cover design, arrangement, and illustration and shows many plants which can be studied with profit to those having similar plants in charge. The book can be had by writing to the Under-Feed Stoker Co., of America, Harris Trust Bldg., Chicago.

HYDRAULIC PUMPS, Catalog No. 81, is the title of a new 120-page, 6 by 9 in. catalog, descriptive of many standard and several new types of hydraulic pumps. This catalog issued and sent free by The Watson-Stillman Co., 50 Church St., New York, contains valuable information for hydraulic engineers and users of hydraulic machinery.

WARREN WEBSTER & CO., Camden, N. J., has just published an interesting and instructive pamphlet entitled "Modulation System of Steam Heating in the Summer Apartments." By studying the drawings of the piping which are clearly reproduced, the general method of application of the Modulation System to apartment house heating may be readily understood. The pamphlet will be sent upon application to the Company at Camden, N. J.

FOR INDICATING or graphically recording the flow of gases, including air, the Cutler Hammer Co., has devised the Thomas meter. It is of a special design, working on a new principle, and has no moving parts. The construction and operation of the flow meter, demonstration of the principles involved, and the accuracy of the records are given in an interesting booklet issued by the Cutler Hammer Mfg. Co.

COCHRANE ENGINEERING LEAFLET No. 10, issued by the Harrison Safety Boiler Works of Philadelphia, Pa., treats of recent developments affecting the use of separators in connection with live and exhaust steam piping. In its 47 pages are found many facts from experience and stories from the day's work that are invaluable for their practical information as well as being interesting reading. The leaflet is well worth sending for.

BULLETIN 93, published by the Wagner Electric Mfg. Co., of St. Louis, describes the Wagner alternating-current rectifier for charging small storage batteries from an alternating current lighting or power circuit.

CONDENSED CATALOG 160 of Bristol's Recording Instruments, is a book which catches the eye at once because of the warm tone of the cover paper, which is an attractive red with embossed black lettering on the cover, and holds the attention because of the interesting information in regard to instruments for recording pressures, voltage, temperature, currents, speed, time and so forth, manufactured by the Bristol Co., of Waterbury, Conn. It shows the instruments, the charts, and scales used, methods of installing the instruments, and shows what they can accomplish in the way of increasing power plant economy and reducing expenses.

REILLY MULTICOIL Feed-Water Heaters, bulletin 206, the V. S. Evaporative Ammonia Condenser, catalog 401, the Goubert Multipass, type G, feed-water heater, bulletin 204, and the Reilly Multicoil Evaporators, catalog 301, are publications recently received from the Griscom-Spencer Co., 90 West Street, New York, and each of them containing a large amount of interesting and useful information on the special product which gives name to the publication.

A NEW FORM OF DRAFT GAGE called the Precision, and having a needle that reads on a dial the same as a voltmeter, is being put out by the Precision Instrument Co., of Detroit, Mich. Further information can be had from catalog E, issued by the company.

VENTURA VENTILATING fans of the disk type, made by the American Blower Co., of Detroit, Mich., are fully described in its bulletin 315, which gives full details as to construction and shows efficiency curves of performance and tables of capacity, sizes and power required to operate.

TRADE NOTES

ABOUT A YEAR AGO the Thermoid Rubber Co. started a prize contest for a motorcycle, a complete set of engineer's tools, a gold watch, and money prizes of $50, $25 and $10. Many engineers have entered it, some of them quite recently, and these feel that not sufficient time has been allowed to make the tests of the Solaroid Red and Blackoid Black Sheet Packings required in the contest. It has, therefore, been decided to extend the time for awarding the prizes to July 1, 1912, by which time all entries and materials for the contest must have been completed.

THE VILTER MFG. CO., Milwaukee, Wis., with offices at 972 Clinton St., Chicago, report the following list of recent sales:

H. D. Foss & Co., Confectioners, Boston, Mass., 30-ton refrigerating plant and 12 by 30 in. direct connected Corliss engine; Arizona Brewing Co., Prescott, Ariz., 42-ton refrigerating machine and 14 by 30 in. Corliss engine; W. C. Welcott, meat dealer, Flint, Mich., 40-ton refrigerating plant, 25-ton brine tank and 14 by 30 in. Corliss engine; Frank A. Patrick, Vancouver, B. C., 2 75-ton refrigerating machines for Vancouver, B. C., 2 75-ton refrigerating machines for Victoria, B. C., for an artificial ice skating rink and curling rink in each of the 2 cities; Calumet Brewing Co., Calumet, Mich., 55-ton refrigerating machine and 15 by 30 in. heavy duty Corliss engine; National Brewing Co., New Orleans, La., 100-ton refrigerating plant, comprising 2 15 by 30 in. direct connected Corliss engines.

IN THE REPORT of the exhibits at the Massachusetts State Convention at Worcester, the name of W. H. Atkinson was included with those of the Federal Metallic Packing Co., of Boston. This was an error as C. W. Tylee was the third representative at the convention.

THE RICHARDSON-PHENIX CO., of Milwaukee, Wis., manufacturers of appliances for lubrication, announces that it has opened a new engineering sales office in Philadelphia, Pa., located in the Real Estate Trust Building. This office is under the management of J. F. McIndoe who has had several years experience in general machinery lubrication and who will give any questions pertaining to this subject prompt and careful attention.

THE PETERSON ENGINEERING CO., lubrication engineers with offices in the Hudson Terminal Building, New York and First National Bank Building, Chicago, and branch offices located throughout the United States, announces that it has taken over from the American Engineering & Manufacturing Co., Inc., of Philadelphia, Pa., the exclusive sale of the Imperial Elevator Guide Lubricator, manufactured by the latter company. This devise will now be known as the Economy Elevator Guide Lubricator.

Recent improvements in this lubricator, it is claimed, enabled it to effect an economy of 10 to 15 per cent in the power consumption of elevators, due to the thorough lubrication of the elevator guides, causing a reduction in the fire hazard, increasing the lifting capacity of the elevator, reducing the oil or grease consumption from 200 to 300 per cent and eliminating all danger of life and limb, necessitated by the old method of hand-swabbing elevator guides from the top of the car.

STEEL CITY ELECTRIC CO., of Pittsburg, Pa., has appointed Aylsworth Agencies Co., 143 Second St., San Francisco, Cal., its Pacific Coast sales representatives. They will carry a large and complete stock of the various material of Steel City manufacture for the convenience of the trade, including Star Bushings, Steel City Drawn Steel outlet boxes, Fullman Adjustable and Non-Adjustable floor outlets, Universal Insulator Supports, Star fixture stems, Superior fish wire, etc., etc., enabling them to make prompt deliveries on all orders received.

THE JOHNS-MANVILLE CO. has a chain of branch stores, warehouses, offices, and factories scattered throughout the United States and Canada, which are under the supervision of the executive officers of the company, whose headquarters will be in its new office building in New York City. Including the space to be afforded in the new general offices, the H. W. Johns-Manville Co., at the present time, occupies in all of its various branches, offices and factories, 2,657,160 sq. ft. of floor space, or about 61 acres. The 5000 employs of the company would in themselves form a good-sized little city. Included in this array of employes are 406 salesmen, traveling through various sections of this country and Canada. In addition, the company has extensive European offices at Hopetoun House, 5 Lloyd's Avenue, London, E. C., and other representatives on the Continent of Europe. The name of H. W. Johns-Manville Co. and Asbestos Magnesia Coverings have so long been synonymous, that many will be surprised to learn that this company also manufactures a large line of electrical goods, plumbers' supplies, building materials, automobile supplies, cold storage insulation materials, railroad supplies, etc.

SCHUCHARDT & SCHUTTE, of New York are placing on the market a new type of high speed universal chuck under the trade name of Columbia. This is especially adapted for heavy work with high-speed steel and has a number of novel features intended to give strength and gripping power. In order to move the jaws out and in for gripping the articles to be held, the Columbia chuck has a spiral thread on the jaws cut V-shaped on a sloping surface, fitting the sloping inside surface of a steel ring. In this way the jaws are given a strong bevel backing of the material of the ring to hold them up to their work instead of depending only on the surface of the threads cut in the jaws. In addition the pitch of the thread is considerably finer than used in the ordinary scroll chuck, thus increasing the gripping power and area of wearing surface. Full descriptions and illustrations will be found in a circular which can be obtained from the manufacturers.

PRACTICAL ENGINEER CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted under regular headings at the rates of 40 cents per line. About nine words make a line. No display type allowed, but the first three words may be set in capital letters. Minimum space sold, two lines.

Under classification, "Positions Wanted," advertisements not exceeding four lines will be inserted for subscribers once free of charge.

To insure proper classification, copy must reach this office on or before the 20th of month preceding publication.

Positions Wanted

POSITION WANTED—As oiler or assistant in power plant by young man of strictly sober habits. Have had some experience with steam, engines and boilers and have completed part of I. C. S. course. Any reasonable offer considered. Address Roy Gibler, White Hall, Ill. 9-1

POSITION WANTED—As assistant or oiler in large power plant or engineer in small plant. Am taking I. C. S. course and have 3 years practical experience in steam, gas and electricity and some experience in refrigeration. Can give best of references. Age 25. Sober and industrious. Address Box 187, Practical Engineer, Chicago, Ill. 9-1

POSITION WANTED—By married man, sober and reliable, with 12 years' experience. Understand A. C. and D. C. electricity and ice machinery. Can give good references. Address Geo. Abel, Ness City, Kansas. 8-2

POSITION WANTED—Engineer would like to take charge of small plant or act as assistant in large one. Have had 7 years' experience. Familiar with the operation of both A. C. and D. C. generators. W. Break, 136 Jones St., Detroit, Mich. 8-3

Help Wanted

WANTED—SUPERINTENDENT FOR ten story, fireproof, office building, having two boilers and four hydraulic elevators and located in a city of 100,000 population in middle West. Man must be married, without children, a competent engineer and general mechanic, capable of successfully handling a force of janitors, elevator men, engineers, etc., keep janitor work up without complaints from tenants, keep boiler room in good condition, see that boilers are fired economically; must be able to do himself, if necessary, various kinds of work common in such a building; must do things promptly. Must not drink, must be faithful and absolutely honest. Must occupy Superintendent's living apartments in building which, including heat and phone, are furnished in addition to salary of $1500.00. Only those need apply who can furnish with application best of references of ability to fill position in every particular. Address Box 185, Practical Engineer, Chicago, Ill. 9-1

AGENTS WANTED TO HANDLE ESTABLISHED steam specialty which is known all over the country. Can be handled with non-conflicting specialties. Will give exclusive agency only for amount of territory actually covered by agent or his salesmen in the following states: Virginia, North Carolina, South Carolina, Oklahoma, Wyoming, Georgia, Arizona, New Mexico, Montana, Idaho, Florida, Arkansas, North Dakota, South Dakota. Address Post Office Box 1754, Pittsburgh, Pa. 9-tf

POWER PLANT EQUIPMENT SALESMAN WANTED—One familiar with the line, to call upon jobbers, consulting engineers, and do missionary work among consumers. In your reply, state experience, references and salary wanted. Address Box 183, Practical Engineer, Chicago, Ill. 9-1

COMPETENT AND EXPERIENCED stoker erectors at once. State age, experience, reference and salary expected. Give full details. Address Box 168, Practical Engineer, Chicago, Ill. tf,

BE AN AGENT FOR Practical Engineer in your city. Pleasant part or whole time work calling on your engineer friends. Liberal cash commission on every subscription taken. Write to Subscription Dept. for information. 7-4

AGENTS WANTED—TO SELL LUBRICATING oils, belts, hose, paint, varnish for power machinery, to factories, mills, auto owners, stores, threshers. Exclusive territory to right party. Oil experience unnecessary. Manufacturers Oil and Grease Co., Cleveland Ohio. 8-tf.

ENGINEERS AND MECHANICS—To make big money selling Incomparable "ZIZ" Hand Soap. A 10-cent can will instantly remove more dirt and stains from the hands than four cakes of any soap made, and will not injure the most delicate skin. Small sample free. Byram Mfg. Co., Box 3133, Boston, Mass. 4-tf.

Wanted

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write the Subscription Dept. They will start you in at once. 7-4

WANTED—5,000 STATIONARY ENGINEERS to send us their name and address. A good proposition open to each one. For full particulars, write Henry W. Lord, 7 S. Greene St., Baltimore, Md.

For Sale

FOR SALE—1 125 H. P., 3-cylinder, Weber Producer Gas Engine. Good as new, used 3 months. Board of Public Works, South Haven, Mich.

FOR SALE—TEN-TON ICE plant located in the city of Pinar del Rio, Cuba; good price for ice, no competition. Machinery of the York and Vilter and in first class condition. Reason for selling have other interest to attend to. Address Thomas J. Howard, 136 Carnegie Hall, New York. 9-1

FOR SALE—One H. S. IDEAL ENGINE, 17x16, 250 Rev. center crank, 2 flywheels 78x20 and 18x14. Endless belt to go with same 68 feet by 18 inches for the sum of $600.00 cash. Address Fred Hohmann, City Clerk, Blue Island, Ill. 7-4

Patents and Patent Attorneys

PATENTS FOR SALE on three different types of steam traps, including the patterns and drawings for same. Address Box 186, Practical Engineer, Chicago, Ill. 9-tf.

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. 7-tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 608 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. 10-tf.

PATENTS—C. L. Parker, late Examiner U. S. Patent Office, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the inventors. Handbook for investors sent upon request. 186 McGill building, Washington, D. C. 4-tf.

Miscellaneous

MAKE MONEY on the side. Here's your chance to pick out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you how. 7-4

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1413 W. Jackson Blvd., Chicago, Ill.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesmen. The Vulcan Soot Cleaner is adapted to all types of boilers. For particulars address G. L. Simonds & Co., No. 803 Steinway Building, Chicago. 7-6